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A MONOGRAPH OF CUNNINGHAMELLA*

ZHENG RU-YONG and CHEN GUI-QING

Systematic Mycology and Lichenology Laboratory
Institute of Microbiology, Academia Sinica
Beijing 100080, China
E-mail: zhengry@sun.im.ac.cn

ABSTRACT

The genus *Cunninghamella* comprises 15 taxa, 12 species and 3 varieties, based on an examination of 197 strains including 151 strains isolated from China and 46 strains obtained from elsewhere. These are: *C. bertholletiae*, *C. binariae* sp. nov., *C. blakesleeana*, *C. clavata*, *C. echinulata* var. *echinulata*, *C. echinulata* var. *antarctica* comb. nov., *C. echinulata* var. *nodosa* var. nov., *C. echinulata* var. *verticillata*, *C. elegans*, *C. homothallica*, *C. intermedia*, *C. multiverticillata* comb. nov., *C. phaeospora*, *C. septata* sp. nov., and *C. vesiculosa*. Four species and one variety are considered to be doubtful: *C. albida*, *C. candida*, *C. echinulata* var. *indica*, *C. indica*, and *C. ramosa*. Three species are excluded from the genus: *C. mandshurica*, *C. meineckella*, and *C. microspora*. Neotypes are designated for *C. bertholletiae* and *C. echinulata* var. *verticillata*. The zygospores in eight of the taxa accepted are unknown, possibly due to the lack of opposite mating type within the same taxon; zygospores of the remaining seven taxa were found. Many characteristics either of the sporangial or the zygosporic states seldom noticed previously were found to be helpful to the classification of *Cunninghamella*. Maximum growth temperature, mating compatibility and molecular systematics were also used as important reference for delimitating species and varieties. A synoptic key and a diagnostic key are provided. Synonyms, descriptions, photographic plates and line drawings are also provided for all the accepted taxa.

KEY WORDS: Cunninghamellaceae, Mucorales, Zygomycetes, Zygomycota, taxonomy.

摘要

研究了小克银汉霉属 (*Cunninghamella*) 的 197 株菌，其中分离自中国的 151 株，自国外征集到的 46 株。共承认 12 种 3 变种组成的 15 分类群： *C. bertholletiae, C. binariae* sp. nov., *C. blakesleeana, C. clavata, C. echinulata* var. *echinulata, C. echinulata* var. *antarctica* comb. nov., *C. echinulata* var. *nodosa* var. nov., *C. echinulata* var. *verticillata, C. elegans, C. homothallica, C. intermedia, C. multiverticillata* comb. nov., *C. phaeospora, C. septata* sp. nov. 和 *C. vesiculosa*。可疑种类包括 4 种 1 变种： *C. albida, C. candida, C. echinulata* var. *indica, C. indica* 和 *C. ramosa*。排除出属的 3 种： *C. mandshurica, C. meineckella* 和 *C. microspora*。在我们承认的分类群中，有 8 个种或变种，由于缺乏各自的相对配合性系而未能形成接合孢子; 其余 7 个分类群的接合孢子阶段则已被找到并进行了研究. 无论是孢子囊阶段或接合孢子阶段的许多鲜为他人注意的特征被认为有助于小克银汉霉属的分类。最高生长温度、性配合亲和性、以及分子系统学亦被用作此属分种分变种时的重要参考. 提供了异名、描述、显微照相图版和线条图. 对某些分类群所作的分类上的改动以及不同分类群之间的关系亦有讨论.

关键词: 小克银汉霉科, 毛霉目, 接合菌纲, 接合菌门, 分类.

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* The project was partially supported by the National Natural Science Foundation of China and the Foundation of the Knowledge Innovation Program of the Chinese Academy of Sciences.

INTRODUCTION

Cunninghamella, the only and type genus of the Cunninghamellaceae (Zygomycetes: Mucorales), was established by Matruchot in 1903. More than 30 names have been introduced in the genus, but only 3 were common to all previously published taxonomies. Table 1 summarizes the status of names published.

Like other members of the Mucorales, species of *Cunninghamella* are traditionally distinguished based solely on their sporangial characters. However, with the exception of a few species like *C. homothallica* Komin. & Tubaki and *C. vesiculosa* P. C. Misra, sporangial characters, which are most frequently used in classification, are often overlapping and the taxa cannot be delimited easily. Identification of taxa is especially difficult owing to the lack of good keys, good descriptions and good illustrations.

Though different authors recognized different species and treated synonymies differently, most of them adopted similar criteria for classifying species (Zycha, 1935; Alcorn & Yeager, 1938; Naumov, 1939; Cutter, 1946; Milko & Beljakova, 1967; Samson, 1969; Zycha *et al.*, 1969; Baijal & Mehrotra, 1980). These included, primarily, colour and texture of colonies; branching pattern of the sporophores; shape and dimension of the vesicles; shape, dimension and colour of the sporangiola; absence or presence of, and length of, spines of the sporangiola.

With the purpose of establishing more acceptable criteria on which to base the separation of species in *Cunninghamella*, Lunn & Shipton (1983) studied sporangial characters of 35 isolates, came to the conclusion that growth rate, growth at 37°C, colony and sporangiolum colour, colony height or texture, presence or absence of rhizoids, sporophore and hyphal diameter, vesicle dimension, and sporophore branching, could not be used to separate species satisfactorily, and resulted in the recognition of 3 species and 1 variety only. Criteria for separating taxa in their key were: homothallic or heterothallic, shape of vesicles, and characters of spines on sporangiola. Thirty-two isolates, including strong mating pairs of *C. echinulata* (Thaxt.) Thaxt. ex Blakeslee, *C. elegans* Lendn., *C. blakesleeana* Lendn. and other isolates of the same or different species, were selected to study their mating reactions. Morphological characters of zygosporangia (as 'zygospores') and suspensors formed in *C. blakesleeana, C. echinulata* and *C. elegans*, were summarized in a table with some interesting findings. Nevertheless, none of the morphological criteria of the zygosporic state was included in their classification.

Recently, the classification of *Cunninghamella* has been based principally on morphology of both the sporangial and zygosporic states. Maximum growth temperature, mating compatibility and zygospore formation, as well as molecular systematics, were used as important criteria for species delimitation. Contributions on morphological classification of certain taxa (Zheng & Chen, 1992, 1994, 1996, 1998), G+C mol% (Zhou & Huang, 1991), RFLPs (Huang *et al.*, 1999), and DNA sequencing of several controversial taxa (Su *et al.*, 1999) have been published. This paper presents a monograph of the genus. Results of sequencing will be published separately (Liu *et al.*, 2001). A total of 197 strains, 151 strains isolated from China and 46 strains obtained from elsewhere, including possibly all

Table 1. Treatments of *Cunninghamella* taxa by different authors.

Cunninghamella	Lendner, 1908	Alcorn & Yeager, 1938	Naumov, 1939	Cutter, 1946	Milko & Beljakova, 1967	Zycha *et al.*, 1969	Samson, 1969	Baijal & Mehrotra, 1980	Lunn & Shipton, 1983	Zheng & Chen, this study
1) *C.* "A"	—	—	—	9	9	—	9	9	—	9
2) *C. africana*	16	√	√	16	16	16	16	16	16	16
3) *C. albida*	√	√	√	?	×	?	?	—	—	?
4) *C. antarctica*	—	—	—	—	—	—	—	—	16	17
5) *C. bainieri*	—	—	◆	√	16	√	16	√	16	21
6) *C. batistae*	—	—	—	—	—	—	22	—	—	32
7) *C. bertholletiae*	—	√	√	√	22	22	22	22	18	√
8) *C. binariae*	—	—	—	—	—	—	—	—	—	◆
9) *C. blakesleeana*	—	√	√	√	√	22	√	√	18	√
10) *C. blakesleeana* var. *verticillata*	—	—	—	—	—	—	—	◊	—	21
11) *C. brunnea*	—	—	—	—	—	—	32	√	16	26
12) *C. candida*	—	—	—	—	—	—	—	—	—	?
13) *C. clavata*	—	—	—	—	—	—	—	—	—	√
14) *C. dalmatica*	—	—	√	?	×	35	16	5	16	21
15) *C. echinata*	—	—	√	9	16	16	16	5	16	21
16) *C. echinulata* var. *echinulata*	√	√	2	√	√	√	√	√	√	√
17) *C. echinulata* var. *antarctica*	—	—	—	—	—	—	—	—	—	◊
18) *C. echinulata* var. *elegans*	—	—	—	—	—	—	—	—	◊	22
19) *C. echinulata* var. *indica*	—	—	—	—	—	—	—	◆	—	?
20) *C. echinulata* var. *nodosa*	—	—	—	—	—	—	—	—	—	◆
21) *C. echinulata* var. *verticillata*	—	—	—	—	—	—	—	—	—	√
22) *C. elegans*	◊	√	√	√	√	√	√	√	18	√
23) *C. elegans* var. *chibaensis*	—	—	—	—	—	—	—	—	—	22
24) *C. homothallica*	—	—	—	—	√	—	√	√	√	√
25) *C. indica*	—	—	—	—	—	—	—	◆	—	?
26) *C. intermedia*	—	—	—	—	—	—	?	—	16	√
27) *C. japonica**	—	—	—	?	22	22	16	5	16	21
28) *C. mandshurica*	—	—	×	×	×	—	×	—	—	×
29) *C. meineckella*	—	—	—	—	—	?	×	—	—	×
30) *C. microspora*	√	√	√	×	×	?	?	—	—	×
31) *C. multiverticillata*	—	—	—	—	—	—	—	—	—	◊
32) *C. phaeospora*	—	—	—	—	22	?	√	√	18	√
33) *C. phaeospora* var. *multiverticillata*	—	—	—	—	—	—	—	—	—	31
34) *C. polymorpha*	—	—	√	?	×	35	√	√	18	7
35) *C. ramosa*	—	—	√	?	×	√	16	—	16	?
36) *C. septata*	—	—	—	—	—	—	—	—	—	◆
37) *C. verticillata*	—	√	√	9	16	16	9	10	18	21
38) *C. vesiculosa*	—	—	—	—	—	—	√	√	√	√

◆ first published as a new taxon; ◊ first published as a new combination; √ accepted; ? doubtful; × excluded; — not mentioned; numeral, treated as synonym of the name in the left column; * as *Actinocephalum japonicum* (basionym of *C. japonica*) by many authors.

of the cultures derived from types now available, have been studied and classified into 12 species and 3 varieties.

MATERIAL AND METHODS

Cultures

Details of materials studied are presented under the description of each taxon. Strains were obtained from the Centraalbureau voor Schimmelcultures, Baarn, Holland (CBS), the Institute for Fermentation, Osaka, Japan (IFO), CAB Bioscience (formerly the International Mycological Institute), Egham, UK (IMI), Cullture Collection Mycothéque l'Université Catholique de Louvain (MUCL), National Institute of Hygienic Sciences, Tokyo, Japan (NHL), and the USDA Agricultural Research Service Collection, Peoria, USA (NRRL); those from China were isolated and identified by us and maintained in the Culture Collection of the Systematic Mycology and Lichenology Laboratory (with a Cu- prefix for *Cunninghamella* spp.) or the AS Culture Collection (with acronym AS), both of Institute of Microbiology, Academia Sinica, Beijing, China. Dried cultures are currently deposited in the Herbarium Mycologicum Instituti Microbiologici Academiae Sinicae (HMAS).

Isolation

Strains found in China were isolated directly from faded flowers, animal excrements, animal and plant debris, fruits and foods kept in moist chambers or placed on agar plates. For particulate material like soil, grains and seeds, the soil plate method of Warcup (1950) was used.

Media and cultivation

Modified SMA (modified synthetic *Mucor* agar which contains dextrose 20 g, asparagine 2 g, KH_2PO_4 0.5 g, $MgSO_4 \cdot 7H_2O$ 0.25 g, thiamine chloride 0.5 mg, agar 20 g in 1000 ml distilled water, pH7) was used for morphological study of the sporangial state; while PDA, also adjusted to pH7, was used for morphological study of the zygosporic state, mating experiment, isolation and maximum growth temperature test. In mating experiment, to ensure better formation of zygospores, 0.2% lecithin was added to the PDA before sterilized and the edge of the petri dishes was sealed with parafilm to maintain moisture after the two mating partners were inoculated. Cultivation period and temperature were 4-10 days at 27-28°C for morphological study of the sporangial state, 8-12 days at 23-25°C (*C. elegans*) or 26-28°C (other species) for morphological study of the zygosporic state and mating experiments, 3-5 days at 27-28°C for isolation, and 4-7 days at different temperatures of 30-50°C for maximum growth temperature test.

Observation and description

When studying the sporangial state morphology, at least 4-10 cultures were grown for each strain and at least 4-6 sites from each culture were chosen for examining under the microscope on each day throughout the 4th to 10th days after inoculation. Descriptions of the sporangial state of all the taxa were based on a comprehensive study of all strains examined. When zygospores were found, description of which was based on a study of the zygosporic state formed by 6-8 pairs of (+) and (−) strains for each taxon if such materials were available.

RESULTS AND DISCUSSION

Maximum growth temperature

A total of 134 strains representing the 15 taxa recognized were tested twice for their maximum growth temperature. For *C. bertholletiae* Stadel, *C. echinulata* var. *echinulata*, *C. echinulata* var. *verticillata* (F. S. Paine) R. Y. Zheng & G. Q. Chen and *C. elegans*, 23, 23, 24, and 25 strains respectively, were tested. For the other taxa with less than 20 strains available, all strains of each taxon were tested. Results obtained are shown in Table 2.

Different strains of the same taxon usually have similar maximum growth temperature. Each taxon appears to have its own specific range of maximum growth temperature. It is also interesting to find that all four varieties included under *C. echinulata* have similar maximum growth temperature. Cutter (1946) was perhaps the first author to use growth temperature as one of the important criteria for separating species in *Cunninghamella*. He distinguished *C. bainieri* Naumov (= *C. echinulata* var. *verticillata*) from *C. echinulata* by its failure to grow at 40°C. It is true that some of the strains of *C. echinulata* var. *echinulata* can, and some of the strains of *C. echinulata* var. *verticillata* cannot, grow at 40°C, but unfortunately, both these two taxa have their maximum growth temperature extending from below, to above 40°C. Hence, the ability to grow at 40°C cannot be used to separate these two taxa. On the other hand, Weitzman & Crist (1980) have successfully applied the same criterion to separate *C. bertholletiae* from *C. elegans*, as the maximum growth temperatures of the two species are 42-43°C and 34-36°C respectively. In the study of Weitzman & Crist (1980), three saprobic isolates of *C. bertholletiae*, NRRL 1375, NRRL 1376, and NRRL 1381, were reported to be unable to grow at 40°C. The first of these, NRRL 1375, is considered to be a new species (*C. binariae* R. Y. Zheng) with a maximum growth temperature of 34°C, while NRRL 1376 and NRRL 1381 are reidentified as *C. phaeospora* Boedijn. As seen in Table 2, the maximum growth temperature of the latter two strains are 34-35°C, and within the range of *C. phaeospora* strains.

Though maximum growth temperature could not be used as the only criterion for separating species, it may play an important role in distinguishing some closely related taxa when combined with other characteristics.

Mating experiments

All the taxa recognized in the present study with (+) and (−) strains resulted in zygospore formation in both intraspecific and intravarietal matings. When different varieties of *C. echinulata* were mated, zygospores were formed between *C. echinulata* var. *echinulata* and *C. echinulata* var.

Table 2. Maximum growth temperature of the *Cunninghamella* taxa

Species & strain	°C	
C. bertholletiae		
CBS 190.84	43, 43	42-43
CBS 191.84	43, 43	
CBS 693.68	43, 43	
NHL 2290	43, 43	
NRRL 1379	42, 42	
NRRL 1380(NT)	43, 43	
NRRL 6428	42, 42	
NRRL 6436	42, 43	
NRRL A-23796	42, 42	
Cu-19	42, 42	
Cu-45	42, 43	
Cu-49	42, 42	
Cu-50	43, 43	
Cu-84	42, 43	
Cu-96	42, 42	
Cu-97	42, 43	
Cu-98	42, 43	
Cu-99	42, 43	
Cu-101	42, 42	
Cu-102	42, 43	
Cu-139	43, 43	
Cu-140	43, 43	
Cu-157	43, 43	
C. binariae		
NRRL 1375 (T)	34, 34	34
C. blakesleeana		
CBS 133.27(T)	37, 38	(36-)37-38
IMI 53585	37, 38	
Cu-53	38, 38	
Cu-54	38, 38	
Cu-63	38, 38	
Cu-80	38, 38	
Cu-81	38, 38	
Cu-82	37, 38	
Cu-83	38, 38	
Cu-89	38, 38	
Cu-143	36, 36	
Cu-144	38, 38	
Cu-166	37, 37	
Cu-181	38, 38	
Cu-200	37, 37	
C. clavata		
Cu-15(T)	35, 35	35
Cu-185	35, 35	
Cu-202	35, 35	
C. echinulata var. *echinulata*		
CBS 156.28(NT)	41, 41	(37-)39-42
CBS 694.68	41, 42	
IMI 198484	40, 40	
MUCL 38718	40, 40	
Cu-16	41, 42	
Cu-24	39, 39	
Cu-33	41, 41	
Cu-38	38, 38	
Cu-41	39, 38	
Cu-62	41, 41	
Cu-71	41, 41	
C. echinulata var. *echinulata* (cont.)		
Cu-90	39, 39	
Cu-91	39, 39	
Cu-94	39, 39	
Cu-153	39, 39	
Cu-160	40, 40	
Cu-161	38, 38	
Cu-171	41, 42	
Cu-172	38, 39	
Cu-178	37, 38	
Cu-196	39, 39	
Cu-204	41, 41	
Cu-224	40, 41	
C. echinulata var. *antarctica*		
CBS 545.75(T)	41, 42	41-42
C. echinulata var. *nodosa*		
Cu-34(T)	41, 41	41
C. echinulata var. *verticillata*		
CBS 134.27	39, 39	(37-)39-42
CBS 148.29	39, 39	
CBS 149.29	39, 39	
CBS 595.68(NT)	41, 42	
CBS 596.68	41, 41	
IMI 191785	38, 38	
IMI 199844	37, 37	
IMI 201275	41, 42	
Cu-20	41, 41	
Cu-22	41, 42	
Cu-29	41, 42	
Cu-30	41, 41	
Cu-32	41, 41	
Cu-37	41, 41	
Cu-39	41, 41	
Cu-47	41, 41	
Cu-51	41, 42	
Cu-57	41, 42	
Cu-66	41, 42	
Cu-73	41, 41	
Cu-78	40, 40	
Cu-88	39, 41	
Cu-103	39, 39	
Cu-209	41, 42	
C. elegans		
CBS 160.28(NT)	35, 35	(34-)35(-36)
IMI 21199	35, 35	
IMI 154138	35, 36	
IMI 199767	34, 34	
IMI 200333	35, 36	
MUCL 16087	35, 35	
MUCL 31518	35, 35	
NRRL 1378	35, 35	
Cu-2	35, 35	
Cu-4	35, 35	
Cu-7	35, 35	
Cu-10	35, 36	
Cu-12	35, 35	
Cu-17	35, 35	
Cu-18	35, 35	

Table 2. Maximum growth temperature of the Cunninghamella taxa (cont.)

Species & strain	°C		Species & strain	°C	
C. elegans (cont.)			*C. phaeospora*		
Cu-58	35, 35		CBS 158.28	35, 34	(32-)34-35
Cu-60	35, 35		CBS 159.28	35, 34	
Cu-61	35, 36		CBS 481.66	35, 34	
Cu-77	35, 35		CBS 692.68(NT)	33, 33	
Cu-85	35, 35		IMI 199346	35, 35	
Cu-95	35, 36		MUCL 10174	34, 34	
Cu-104	35, 35		NRRL 1376	35, 34	
Cu-189	35, 36		NRRL 1381	35, 35	
Cu-203	35, 35		Cu-113	32, 32	
Cu-207	35, 35		Cu-116	34, 33	
C. homothallica			Cu-136	35, 35	
IFO 6736 (T)	37, 37	37	Cu-199	34, 34	
C. intermedia			*C. septata*		
CBS 347.69	43, 43	43	Cu-230(T)	35, 35	35
IMI 200623 (T)	43, 43		*C. vesiculosa*		
C. multiverticillata			NRRL 3009(T)	36, 37	36-37
Cu-137 (T)	41, 42	41-42			

verticillata, but no response could be detected either among *C. echinulata* var. *antarctica* (Caretta & Piont.) R. Y. Zheng & G. Q. Chen, *C. echinulata* var. *nodosa* R. Y. Zheng and *C. echinulata* var. *echinulata* or *C. echinulata* var. *antarctica*, *C. echinulata* var. *nodosa* and *C. echinulata* var. *verticillata*. Possible reasons may be that the only strains of both *C. echinulata* var. *antarctica*, CBS 545.75, and *C. echinulata* var. *nodosa*, Cu-34, are very weak in their mating ability, or do not have an affinity close enough to form zygospores with the other varieties of the same species.

Mating ability differred not only among different strains of the same taxon but among different species within the genus. For example, as a species, *C. blakesleeana* has very strong mating ability, nearly all of the (+) and (−) strains when being brought together formed zygospores; while in *C. bertholletiae*, except Cu-19(+), most of the (+) strains did not form zygospores with most of the (−) strains of this species.

Most strains of all taxa did not react in interspecific matings. A few formed gametangia with a certain number of opposite strains, and two crosses, Cu-19(+, *C. bertholletiae*) × Cu-81(−, *C. blakesleeana*) and Cu-137[+, *C. multiverticillata* (R. Y. Zheng & G. Q. Chen) R. Y. Zheng] × NHL 2290(−, *C. bertholletiae*), resulted in zygosporangium formation. Exceptions of forming zygospores in interspecific matings were found between *C. binariae* and *C. bertholletiae* in the following two crosses: NRRL 1375(+) × CBS 693.68(−) and NRRL 1375(+) × NRRL A-23796(−), as well as between *C. multiverticillata* and *C. phaeospora* in one cross: Cu-137(+) × Cu-136(−). The reasons for still retaining these as distinct are discussed under the description of each of the taxa concerned.

The three strains of *C. clavata* R. Y. Zheng & G. Q. Chen did not form zygospore among one another but formed gametangia each with several to many (−) strains of the other species, thus revealing all of them are of (+) mating type. The only strain of *C. vesiculosa*, NRRL 3009, did not react with most of the strains tested except Cu-185 (= AS 3.5004, *C. clavata*). Since Cu-185 is a (+) strain, NRRL 3009 is (−) in its mating type. The mating types of CBS 545.75 (*C. echinulata* var. *antarctica*), Cu-34 (*C. echinulata* var. *nodosa*), IMI 200623 (*C. intermedia* K. B. Deshp. & Mantri), CBS 347.69 (also *C. intermedia*, originally type of *C. brunnea* J. N. Rai *et al.*) and Cu-230 (*C. septata* R. Y. Zheng) are not determinable, as they did not interact with any of the strains tested.

Morphological studies

Many morphological characteristics, both of the sporangial and zygosporic states, have been found to be usable as taxonomic criteria in distinguishing the taxa of *Cunninghamella*. Some of the criteria, like the branching type of sporophores, are usually very diverse in the same species or variety and at the same time, overlap among different species or varieties. However, the majority of sporophores in one taxon often have their own unique style. Therefore, branching type of sporophores can still be accepted as one of the most important criteria for classifying species or varieties. When more criteria are taken into consideration, the taxa can be separated more easily and more satisfactorily. For example, if only the colour of colonies, branching type of sporophores, shape and dimension of vesicles and sporangiola are used to compare *C. bertholletiae* and *C. elegans*, they are almost inseparable. When more criteria like equality of lengths of branches from the same sporophore, presence or absence of terminal vesicles on the main stems of sporophores, equality of the two suspensors supporting a zygosporangium, shape and diameter, and especially length, of the suspensors, as well as the maximum growth temperature are also compared, the two species can be separated quite easily. Some criteria which are indistinguishable among certain taxa, may become very distinct among others. The verticillate or pseudoverticillate branching type of sporophores which is found in many taxa, has never been encountered in *C. homothallica* and *C. vesiculosa*.

Morphological characteristics useful in classifying *Cunninghamella* taxa are summarized in the Synoptic Key. These characters are stable for nearly all the strains studied. Even the colour of colonies which was stated to show "wide variations in colour within species" by Lunn & Shipton (1983), is believed to be a reliable character. Fifty-one, out of the fifty-two strains of *C. echinulata* var. *verticillata* isolated from many countries and many regions in China, exhibit a uniform cream to brownish cream colony colour. The only exception being CBS 134.27, originally reported by Ling (1930) from France as *Muratella* sp. The culture, which might be an albino mutant of the species, is persistently white though its microscopic characteristics conform well with the other strains of this taxon. Nevertheless, in other taxa, the colours of all the strains of the same taxon are almost the same.

Details of the morphology studied are discussed under the description of each taxon. Plates I-VI show comparatively typical morphology of the species accepted except the new taxa described in this paper, i.e. *C. binariae, C. echinulata* var. *nodosa* and *C. septata,* which are being arranged in the separate plates of Plates. VII-IX.

TAXONOMY

Cunninghamella Matr., Ann. Mycol. 1: 47. 1903.

= *Actinocephalum* Saito, Bot. Mag. Tokyo 19: 36. 1905.
= *Saitomyces* Ricker, J. Mycol. 12: 61. 1906.
= *Muratella* Bainier & Sartory, Bull. Soc. Mycol. Fr. 29: 129. 1913.

Colonies usually floccose, sometimes granulate, white to faintly or deeply coloured, growing rapidly. *Hyphae* branching, non-septate when young, septate in age. *Stolons* present or absent. *Rhizoids* scanty to abundant, arising from the aerial mycelia or from various parts of the thallus, long or short, simple to profusely branched. *Sporophores* either of one type, the longer type, or of two types, the longer and shorter types; the longer type of sporophores erect, straight or recumbent, arising from stolons, rarely opposite rhizoids, or directly from aerial hyphae and stolon-like, main axes of the sporophores verticillately, pseudoverticillately, monopodially, sympodially, or irregularly branched, with a terminal vesicle or sometimes without a terminal vesicle and directly branched into several branches; the shorter type of sporophores usually erect and much shorter and smaller, mostly simple, rarely with one side branch, always with a terminal vesicle. *Vesicles* formed terminally on the main stems and the branches, globose, subglobose, ovoid, clavate, or irregularly shaped. *Pedicels* formed over the entire, or only the upper portion, of the vesicles. *Sporangiola* borne on pedicels, hyaline, brownish to brown in colour, sparsely to thickly echinulate, unispored. *Sporangiospores* detachable, but usually remaining within the sporangiola, hyaline, similar in shape and size to the sporangiola bearing them. *Chlamydospores* usually absent. *Zygosporangia* globose, subglobose, or depressed globose, reddish-brown to dark brown when mature, with blunt to pointed wart-like projections, unispored. *Zygospores* formed inside the zygosporangia, globose, subglobose to broadly ellipsoid, hyaline, subsmooth to indistinctly ridged, rarely tuberculate. *Suspensors* opposed, non-appendaged, equal or unequal, symmetrically or unsymmetrically inflated, constricted or nonconstricted at the base, subhyaline, pale orange, or light brown, smooth, roughened to heavily incrusted. *Homothallic* or *heterothallic*.

Maximum growth temperature: 32-43°C

DNA length of respectively ITS1, 5.8S, ITS2 and entire ITS region: 228-328, 153-156, 203-428 and 611-844 bp

G + C mol%: 27-30

Type species: *Cunninghamella echinulata* (Thaxt.) Thaxt. ex Blakeslee

In early studies, *Cunninghamella* was placed in Chaetocladiaceae (Lendner, 1908) or Choanephoraceae (Matruchot, 1903; Fitzpatrick, 1930; Zycha, 1935; Christenberry, 1940; Bessey, 1950; Rayss & Borut, 1958; Zycha *et al*., 1969). After the establishment of the Cunninghamellaceae by Naumov (1939), most authors accepted the family though the genera accompanying *Cunninghamella* in the family varied greatly (Ou, 1941; Cutter, 1946; Hesseltine, 1952, 1955; Benjamin, 1959, 1979; Teng, 1963, 1996; Milko & Beljakova, 1967; Pidoplichko & Milko, 1971; Hesseltine & Ellis, 1973; Milko, 1974). The genera which were put together with *Cunninghamella* in the Cunninghamellaceae had been assigned one after another to other families and finally, with the removal of the last two genera *Sigmoideomyces* and *Thamnocephalis* to a new family Sigmoideomycetaceae by Benny *et al*. (1992), *Cunninghamella* is now the only genus retained in the Cunninghamellaceae. This is doubtless the most natural treatment for the systematic position of *Cunninghamella* and has already been followed by Hawksworth *et al*. (1995).

Names in *Cunninghamella* and their taxonomic status according to some of the more important authors working on the group are listed in Table 1. As seen from the table, classification of *Cunninghamella* differs significantly according to different authors. In the present study, twelve species and three varieties are recognized. Among which, one is a recently described species found in China: *C. clavata* (Zheng & Chen, 1998); one is based on NRRL 1375 received as *C. bertholletiae* but found to be a new species: *C. binariae* (this study); one is isolated from a mixed culture of MUCL 16087 and found to be a new species: *C. septata* (this study); one is a new variety: *C. echinulata* var. *nodosa* (this study); three are new combinations: *C. echinulata* var. *verticillata* (Zheng & Chen, 1996), *C. echinulata* var. *antarctica* (this study), and *C. multiverticillata* (this study); the remaining eight are previously recognized taxa: *C. bertholletiae*, *C. blakesleeana*, *C. echinulata* var. *echinulata*, *C. elegans*, *C. homothallica*, *C. intermedia*, *C. phaeospora* and *C. vesiculosa*. Two of our previously accepted species, *C. polymorpha* Pišpek and *C. brunnea* Rai *et al.* (Zheng & Chen, 1992), are now considered to be synonymous with *C. bertholletiae* and *C. intermedia* respectively. Four species and one variety are considered to be doubtful: *C. albida* (Sacc.) Matr., *C. candida* Yamam., *C. echinulata* var. *indica* Baijal & B. S. Mehrotra, *C. indica* Baijal & B. S. Mehrotra, and *C. ramosa* Pišpek. Three species are excluded from the genus: *C. mandshurica* Saito & H. Nagan., *C. meineckella* Olson, and *C. microspora* (Riv.) Matr.

Important characters for characterizing the taxon are listed under each taxon. A synoptic key and a diagnostic key are provided for classifying the taxa.

KEY TO THE SPECIES AND VARIETIES OF *CUNNINGHAMELLA* BASED ON THEIR SPORANGIAL, ZYGOSPORIC, AND OTHER NON-MORPHOLOGICAL CHARACTERISTICS

Synoptic Key

Abbreviation:

C. bertholletiae	*be*
C. binariae	*bi*
C. blakesleeana	*bl*
C. clavata	*cl*
C. echinulata var. *echinulata*	*ec*
C. echinulata var. *antarctica*	*an*
C. echinulata var. *nodosa*	*no*
C. echinulata var. *verticillata*	*vt*
C. elegans	*el*
C. homothallica	*ho*
C. intermedia	*in*
C. multiverticillata	*mu*
C. phaeospora	*ph*
C. septata	*se*
C. vesiculosa	*vs*

I. *Colonies*:

A. Colour on SMA at 27-28°C, 5-7 days after incubation:
- Remaining white — *vs*
- White when young, changing to pale yellowish or greyish in age — *bl, cl, ho, mu*
- Cream to brownish cream — *ec, an, no, vt, se*
- Grey to dark grey — *be, bi, el, in, ph*

B. Texture:
- Often finely to heavily granulated — *an, vt, se*
- Usually cottony and not granulated — *be, bi, bl, cl, ec, no, el, ho, in, mu, ph, vs*

II. *Sporophores*:

A. With one type or two intergrading types of sporophores:
- One type — *be, bi, bl, el, ho, in, mu, ph, se, vs*
- Two types — *ec, no*
- Usually one type, occasionally two types — *cl, an, vt*

B. Diameter of the main axes of sporophores:
- 3.5-10 μm — *ho, vs*
- 5-15(-18.5) μm — *be, bl, cl, ec, no, el, in, mu, ph*
- 7.5-25 μm — *bi, an, vt, se*

C. Equality of width in the main axes of sporophores:
- Mainly equal to subequal throughout — *bl, cl, ec, el, ho, in, mu, ph, vs*
- Usually broadening upwards — *be, bi, an, no, vt, se*

D. Branching type of the primary branches:
- Monopodial — *no, ho, in*
- Monopodial and verticillate — *bl, el, mu, ph*
- Monopodial and pseudoverticillate — *cl, ec*
- Monopodial, verticillate and pseudoverticillate — *be, bi, an, vt*
- Sympodial and irregular — *se, vs*

E. Approximate number of primary branches per sporophore:
- 0-1 — *ho*
- 0-4(-8) — *bl, cl, ec, no, ph, se, vs*
- (0-)2-10(-18) — *be, bi, an, el, mu*
- (0-)4-15(-25) — *vt, in*

F. Approximate length of branches:
- 10-100(-250) μm — *bl, no, vt, el, mu, ph, se, vs*
- 10-200(-500) μm — *bi, ec, an, ho, in*
- 10-500(-800) μm — *be, cl*

G. Equality of lengths of branches from the same sporophore:
- Typically long and short — *be, bi, cl, an, in, se*
- Mainly subequal but may also be long and short — *ec, no, vs*
- Subequal — *bl, vt, el, ho, mu, ph*

H. Distance between branches or verticils from the same sporophore:
- Very compact — *vt, in, se*
- Comparatively compact — *be, bi, cl, ec, an, no, vs*
- Comparatively remote — *bl, el, ho, mu, ph*

I. Direction of branches:
- Mostly horizontal or upwards — *be, bi, bl, cl, ec, an, no, vt, el, ho, mu, ph, vs*
- Pointing in all directions — *in, se*

- J. Frequency of branching:
    - Mostly 0-1(-2) — *bl, no, vt, el, ho, mu, ph*
    - Mostly (0-)1-3(-4) — *be, bi, ec, an, in, vs*
    - Mostly (0-)1-3(-7) — *cl*
    - Mostly (1-)2-6(-12) — *se*
- K. Septation:
    - Usually absent — *bl, el*
    - Usually present but few — *be, bi, cl, ec, an, no, vt, ho, in, mu, ph, vs*
    - Usually present and many — *se*
- L. Sterile branches:
    - Usually present — *ho, vs*
    - Occasionally present — *an, bi, no, se*
    - Usually absent — *be, bl, cl, ec, vt, el, in, mu, ph*

III. *Vesicles*:

- A. Presence or absence of terminal vesicles on the main axes of sporophores:
    - Always present — *bl, cl, ec, el, ho, in, mu, ph, se*
    - Occasionally absent — *bi, no, vt, vs*
    - Not infrequently absent — *be, an*
- B. Shape:
    - Globose, subglobose, or ovoid, rarely irregular in the terminal ones — *be, bl, an, el, in*
    - Globose, subglobose, or ovoid, quite often irregular in the terminal ones — *bi, ph*
    - Globose, subglobose, ovoid, or subclavate — *ec, no, ho, mu, se*
    - Depressed globose to subglobose — *vt*
    - Clavate or subclavate — *cl*
    - Inflated in the lower 4/5 part — *vs*
- C. Approximate diameter of terminal vesicles on the main axes:
    - 9-27.5 μm — *ho, mu, vs*
    - 10-33(-42) μm — *be, bi, bl, cl, ec, no, el; in, ph, se*
    - 17-45(-70) μm — *an, vt*
- D. Angularity:
    - Evidently angular — *in*
    - Somewhat angular — *no, mu, ph*
    - Usually not angular, rarely angular — *se*
    - Not angular — *be, bi, bl, cl, ec, an, vt, el, ho, vs*

IV. *Pedicels*:

- A. Approximate length:
    - 1.5-2 μm — *ho, vs*
    - 2-3.5(-7) μm — *be, bi, bl, ec, an, vt, el, in, mu, ph, se*
    - 2.5-9(-11) μm — *cl, no*

V. *Sporangiola*:

- A. Shape:
    - Exclusively globose — *cl, in*
    - Globose and broadly ovoid — *no, ho, vs*
    - Globose, ovoid and lacrymoid — *be, bi, bl, ec, an, vt, el, mu, ph, se*
- B. Presence or absence of dark giant globose sporangiola:
    - Usually present and abundant after 5 days — *ec, vt*
    - Present but few after 5 days — *an*
    - Present and abundant after 16 days — *no*
    - Absent — *be, bi, bl, cl, el, ho, in, mu, ph, se, vs*

- C. Echinulation:
  - Long and thick — *ec, vt, vs*
  - Moderately long and thick — *bi, an, no, ho, se*
  - Short and thick — *cl, el, in, mu, ph*
  - Short and sparse — *be, bl*
- D. Colour:
  - Subhyaline — *bl, se, vs*
  - Subhyaline to brownish — *be, bi, el, ho, mu*
  - Brownish to brown — *cl, in, ph*
  - Partly subhyaline and partly dark brown — *ec, an, no, vt*
- E. Approximate diameter of globose sporangiola (giant dark sporangiola not included):
  - 5-9(-11) µm — *be, bi, el*
  - (5-)8-14(-17) µm — *bl, ec, an, no, vt, mu, ph*
  - 8-14(-23) µm — *ho, in*
  - 9-20(-28) µm — *cl, se, vs*
- F. Approximate length of ovoid or lacrymoid sporangiola:
  - Up to 16 µm — *be, no, mu, ph*
  - Up to 22 µm — *ec, an, vt, el, ho, se, vs*
  - Up to 32 µm — *bi, bl*

VI. *Zygosporic state*:

- A. Discovery:
  - Found — *be, bl, ec, vt, el, ho, ph*
  - Not yet found — *bi, cl, an, no, in, mu, se, vs*
- B. Type of sexual reproduction:
  - Heterothallic — *be, bl, ec, vt, el, ph*
  - Homothallic — *ho*

VII. *Zygosporangia*:

- A. Shape:
  - Globose to subglobose — *ec, vt, ho*
  - Irregularly globose to subglobose — *be*
  - Slightly depressed-globose to subglobose — *el, ph*
  - Mainly depressed-globose — *bl*
- B. Colour:
  - Reddish brown — *bl, el, ph*
  - Dark brown — *be, ec, vt, ho*
- C. Diameter:
  - Up to 50 µm — *be, ho*
  - Up to 62 µm — *ec, vt, el, ph*
  - Up to 73 µm — *bl*
- D. Protuberance:
  - Somewhat pointed — *ec, vt, ho*
  - Blunt — *be, bl, el, ph*

VIII. *Zygospores*:

- A. Wall thickness:
  - Thin — *be, bl*
  - Medium — *ec, el, ph*
  - Thick — *vt, ho*
- B. Ornamentation:
  - Tuberculate — *ho*
  - With indistinct ridges — *be, bl, ec, vt, el, ph*

IX. *Suspensors*:
A. Equality of the two suspensors supporting a zygosporangium:
Equal — *be, ec, vt, ho, ph*
Unequal — *bl, el*
B. Symmetry of the inflated suspensors:
Symmetrically inflated — *bl, ho, ph*
Asymmetrically inflated — *el*
C. Maximum diameter:
Usually not exceeding 18 µm — *be*
Up to 30 µm — *ec, vt, ho*
Up to 35 µm — *el, ph*
Up to 45 µm — *bl*
D. Diameter of the base:
Usually not exceeding 10 µm — *be, bl, el, ho, ph*
Up to 20 µm — *ec, vt*
E. Length:
Usually not exceeding 40 µm — *ec, vt, el, ho*
Up to 50(-73) µm — *bl, ph*
Up to 80(-92) µm — *be*
F. Septation at the base:
Usually absent — *el, ho*
Present or absent — *be, bl, ec, vt, ph*
G. Colour:
Subhyaline to light brown — *be, ec, vt, ph*
Orange, partly light brown — *bl, el, ho*
H. Ornamentation of the wall:
Usually smooth, occasionally roughened — *be, ec, vt*
Smooth or roughened and incrusted — *el, ph*
Usually roughened and heavily incrusted — *bl, ho*

X. *Non-morphological characteristics*:
A. Maximum growth temperature:
(32-)34-36°C — *bi, cl, el, ph, se*
36-38°C — *bl, ho, vs*
(37-)39-42°C — *ec, an, no, vt*
41-43°C — *be, in, mu*
B. DNA length (bp) of respectively ITS1, 5.8S, ITS2, and entire ITS region as represented by the ex-type culture of the taxon:
241, 155, 215, 611 — *ho*
257, 154, 204, 615 — *el*
281, 154, 205, 640 — *bi*
282, 155, 204, 641 — *ph*
283, 155, 220, 658 — *bl*
291, 155, 218, 664 — *mu*
328, 154, 199, 681 — *cl*
318, 154, 213, 685 — *be*
302, 156, 311, 769 — *vs*
285, 155, 343, 783 — *in*
228, 154, 419, 801 — *ec*
235, 153, 419, 807 — *no*

236, 154, 420, 810 — *an*
237, 155, 428, 820 — *vt*
273, 154, 417, 844 — *se*

Dichotomous Key

1. Homothallic; sporophores simple or with one side branch only; zygospores tuberculate; average DNA length of entire ITS region 611 bp .... ***C. homothallica***
1. Heterothallic; sporophores often with more branches; zygospores with indistinct ridges and not tuberculate; DNA length of entire ITS region longer 2
2. Colonies very low and flat, not exceeding 1 mm high; aerial mycelia absent, sporophores arising directly from substrate mycelia; growing very slow, reaching 9 cm diam. in 2 weeks on SMA at 25-27°C; branches of sporophores branching typically in a zigzag pattern up to 12 times; with many septa; DNA length of entire ITS region 844 bp .... ***C. septata***
2. Colonies higher and exceeding 1 mm high; aerial mycelia present, sporophores not arising directly from substrate mycelia; growing faster, reaching 9 cm diam. in 4-5 days on SMA at 25-27°C; branches of sporophores not branching in a zigzag pattern and never repeatedly branched so many times; without septa or with a few septa only; DNA length of entire ITS region shorter 3
3. Colonies persistently white; vesicles typically inflated in the lower 4/5 part and narrowed in the upper 1/5 part; sporophores sympodially or irregularly branched; DNA length of entire ITS region 769 bp .... ***C. vesiculosa***
3. Colonies at first white, then pigmented; vesicles globose, subglose, ovoid, clavate or irregular; sporophores not sympodially or irregularly branched; DNA length of entire ITS region longer or shorter 4
4. Sporangiola exclusively globose 5
4. Sporangiola not exclusively globose 6
5. Colonies pale greyish; vesicles clavate, not angular; branches of sporophores branching 1-3(-7) times, typically at right angles and arising just beneath the vesicle of the former branch when repeatedly branched; pedicels 2.5-9(-11) μm long; maximum growth temperature 35°C; DNA length of entire ITS region 681 bp .... ***C. clavata***
5. Colonies deep grey; vesicles globose or subglobose, evidently angular; branches of sporophores branching 1-3(-4) times, irregularly directed in all directions; pedicels 2-3.5(-6) μm long; maximum growth temperature 43°C; DNA length of entire ITS region 783 bp .... ***C. intermedia***
6. Colonies cream to brownish cream; with two intergrading types of sporophores; dark giant sporangiola present in old cultures; base of suspensors often not constricted, reaching 20 μm diameter; maximum growth temperature (37-)39-42°C 7
6. Colonies not cream to brownish cream; with one type of sporophores only; dark giant sporangiola absent in old cultures; base of suspensors often constricted, not exceeding 10 μm diameter; maximum growth temperature lower or higher 10
7. Sporophores typically nodulous; sporangiola globose and broadly ovoid; dark giant sporangiola present after 16 days; vesicles somewhat angular; pedicels 4.5-7.5(-10) μm long; DNA length of entire ITS region 807 bp .... ***C. echinulata*** var. ***nodosa***
7. Sporophores not nodulous; sporangiola globose, broadly ovoid and lacrymoid; dark giant sporangiola present after 5 days; vesicles not angular; pedicels 2-4(-7.5) μm long; DNA length of entire ITS region longer or shorter 8
8. Sporophores with or without a terminal vesicle on the main axis; branches typically

long and short in the same sporophore and repeatedly branched; dark giant sporangiola relatively rare to few; zygosporic state not yet found; DNA length of entire ITS region 810 bp .... ***C. echinulata*** var. ***antarctica***

8. Sporophores usually with a terminal vesicle on the main axis; branches mainly similar in length but sometimes rarely long and short in the same sporophore and usually not repeatedly branched; dark giant sporangiola usually present and abundant; zygosporic state found; DNA length of entire ITS region longer or shorter 9

9. Two types of sporophores common; no verticillate branches found in the sporophores, primary branches of sporophore 0-4(-10) in number, not short and compact; terminal vesicles on the main axes globose to subglobose, 13-30(-40) μm diameter; DNA length of entire ITS region 801 bp .... ***C. echinulata*** var. ***echinulata***

9. Two types of sporophores sometimes encountered; sporophores usually with many whorls of verticillate or pseudoverticillate branches, primary branches of sporophore (0-)4-15(-25) in number, short and compact; terminal vesicles on the main axis somewhat depressed globose, 22-50(-70) μm diameter; DNA length of entire ITS region 820 bp .... ***C. echinulata*** var. ***verticillata***

10. Colonies pale yellow, rarely pale greyish-yellow; sporangiola large, reaching 32 × 16 μm or 17.5 μm diameter, sparsely and shortly echinulate; zygosporangia depressed globose, reaching 73 μm diameter; suspensors reaching 45 μm diameter; maximum growth temperature 36-38°C; DNA length of entire ITS region 658 bp .... ***C. blakesleeana***

10. Colonies light or deep grey; sporangiola usually smaller and not exceeding 22.5 × 11 μm (rarely reaching 32 μm long) or 13 μm diameter, densely echinulate; zygosporangia when found usually not depressed globose and not exceeding 60 μm diameter; maximum growth temperature lower or higher than 36-38°C; DNA length of entire ITS region longer or shorter 11

11. Main axes of sporophores usually enlarging upwards; branches typically long and short in the same sporophore and repeatedly branched; zygosporangia irregularly globose to subglobose, reaching 50 μm diameter; suspensors reaching 80(-92) μm in length but not exceeding 18 μm diameter 12

11. Main axes of sporophores usually not enlarging upwards; branches subequal in length in the same sporophore and not repeatedly branched; zygosporangia mainly globose to subglobose, reaching 62 μm diameter; suspensors not exceeding 40 μm in length but reaching 30-35 μm diameter 13

12. Branches of sporophores typically binary; sterile branches sometimes present; axial vesicles present and sometimes irregularly shaped; lacrymoid sporangiola reaching 32 μm in length; DNA length of entire ITS region 640 bp .... ***C. binariae***

12. Branches of sporophores not binary; sterile branches absent; axial vesicles present or absent, usually not irregularly shaped when present; larymoid sporangiola reaching 16 μm in length; DNA length of entire ITS region 685 bp .... ***C. bertholletiae***

13. Vesicles rather regular in shape, globose, subglobose to broadly ovoid, smooth; sporangiola ovoid, oblong-ovoid, lacrymoid, rarely globose, length : width ratio approximately 3 : 1.5-2(-3); suspensors typically unequal, one often asymmetrically inflated and ear-shaped; DNA length of entire ITS region 615 bp .... ***C. elegans***

13. Vesicles somewhat variable, ovoid, subglobose, clavate to irregular, often indistinctly angular; sporangiola mostly globose or subglobose, sometimes lacrymoid, length : width ratio approximately 3: 2-3; suspensors typically equal and symmetrically inflated; DNA length of entire ITS region longer 14

14. Colonies deep grey; rhizoids not abundant, arising from hyphae only; sporophores

mainly simple or monopodially branched; branches solitary or in pairs, very rarely verticillate or pseudoverticillate; vesicles of the lateral branches subovoid to subglobose, rarely subclavate; sporangiola brownish to dark brown; maximum growth temperature (32-)34-35°C; DNA length of entire ITS region 641 bp .... ***C. phaeospora***

14. Colonies dirty white to pale greyish; rhizoids abundant, arising from various parts of the hyphae, stolons, sporophores or vesicles; sporophores partly monopodially, partly verticillately, or more often a combination of both monopodially and verticillately branched; branches solitary, in pairs or 1-3 whorls of 3-8; vesicles on lateral branches frequently clavate; sporangiola hyaline to brownish; maximum growth temperature 41-42°C; DNA length of entire ITS region 664 bp .... ***C. multiverticillata***

Cunninghamella bertholletiae Stadel, Über einen neuen Pilz, *Cunninghamella Bertholletiae*, Dissertation, Kiel, p. 7. 1911. (Figs. 1a, 1b; Pl. III: 1, 2; Pl. IV: 1; Pl. V: 1, 2; Pl. VII: 6, 7)

= *Cunninghamella polymorpha* Pišpek, Acta Bot. Inst. Bot., Zagreb 4: 103. 1929.

= *Cunninghamella elegans* sensu auct.: Lendner, Bull. Soc. Bot. Genèva 19: 23. 1927. p.p.; Zycha, Mucorineae. *In*: Rabenhorst, Kryptogamenflora der Mark Brandenburg VIa. p. 168. 1935. p.p.; Milko & Beljakova, Mikrobiologiya 36: 686. 1967. p.p.; Zycha, Linnemann & Siepmann, Mucorales. p. 148. 1969. p.p.; Samson, Proc. Kon. Ned. Akad. Wet., Ser. C, 72: 325. 1969. p.p.; Baijal & Mehrotra, Sydowia 33: 10. 1980. p.p.; non Lendner, Bull. Herb. Boissier 7: 250. 1907.

≡ *Cunninghamella echinulata* var. *elegans* (Lendn.) Lunn & Shipton, Trans. Brit. Mycol. Soc. 81: 312. 1983. p.p.

Colonies on SMA floccose, reaching 9 cm diam. in 5 days at 28°C, about 1 cm high or higher, at first white, soon becoming grey, deep grey to brownish grey ('Drab Grey', Ridgway XLVI, to 'Mouse Grey', Ridgway LI), margin paler, reverse greyish white. *Hyphae* branching, non-septate when young, septate in age, 2.5-11.5 μm diam. *Stolons* sometimes present. *Rhizoids* usually simple and finger-like, long or short. *Sporophores* erect, straight or recumbent, arising from stolons, rarely opposite rhizoids, or directly from aerial hyphae and stolon-like; main axes of the sporophores slightly enlarging upwards, sometimes equal in width throughout, 6-15 μm diam., hyaline, somewhat brownish at the lower portion, terminated with a vesicle or dividing into 2-many branches at the apices; branches monopodial, pseudoverticillate, verticillate, or irregular, typically long and short in the same sporophore, up to 600 μm long, repeatedly branching 1-3 times, all terminated with a vesicle. *Septa* in sporophores present. *Vesicles* mostly globose, subglobose to ovoid, rarely irregular, axial vesicles 19-42.5 μm diam., lateral vesicles 7.5-27.5 μm diam., hyaline, rarely brownish, usually smooth, proliferation of vesicles sometimes occurring, giving rise to numerous pedicels over their entire surfaces. *Pedicels* 2-3.5(-5.5) μm long. *Sporangiola* borne on pedicels on vesicles, ovoid, ellipsoid, subglobose, with or without a pointed end, 5-14.5(-16) × 3.5-9(-11) μm or 4.5-9(-11) μm diam., hyaline to pale brownish, subsmooth to very shortly echinulate, monosporous. *Sporangiospores* detachable, but usually remaining in the sporangiola, spineless, tuberculate, hyaline, similar in shape and size to the sporangiola bearing them. *Chlamydospores* absent. *Zygosporangia* irregularly globose to subglobose, slightly compressed between the suspensors, 24-47.5 μm diam., dark brown when mature, warted, with blunt projections, monosporous. *Zygospores* ellipsoid, irregularly globose to subglobose, 20.5-44 μm diam., outer wall very thin, crenulate, with indistinct ridges, hyaline. *Suspensors* mainly equal in shape but unequal in length, rarely unequal in shape, smooth, very seldom incrusted, usually not inflated, but one or both of the suspensors may becoming inflated, with or without a septum at the base, straight, sometimes abruptly bending, typically long and slender, 14-80(-92) μm

See Errata

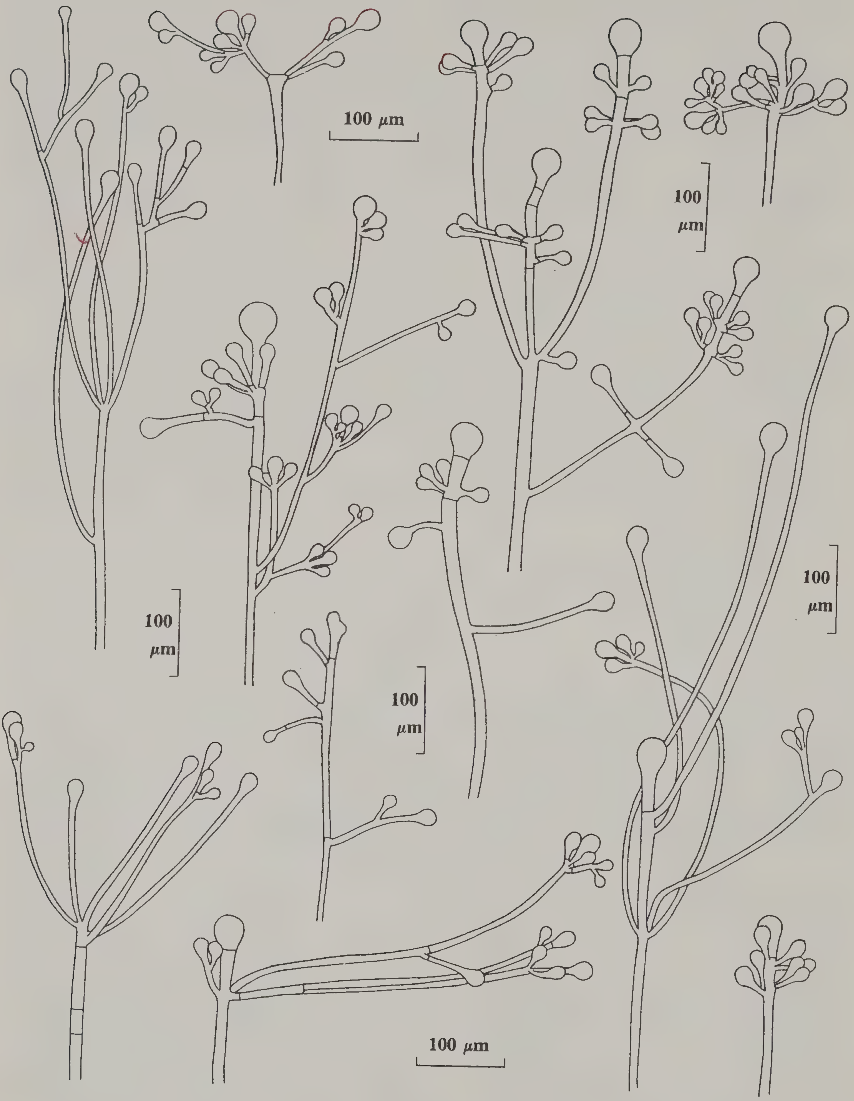

Fig. 1a. *Cunninghamella bertholletiae*. Terminal portions of sporophores showing characteristic branching patterns. Note that many of the sporophores broaden upwards and either terminate in, or do not terminate in a vesicle and directly divide into two to many branches at the apex of the main axis; the branches are typically long and short in the same sporophore and may repeatedly branch 1-3 times. [NRRL 1380, neotype].

See

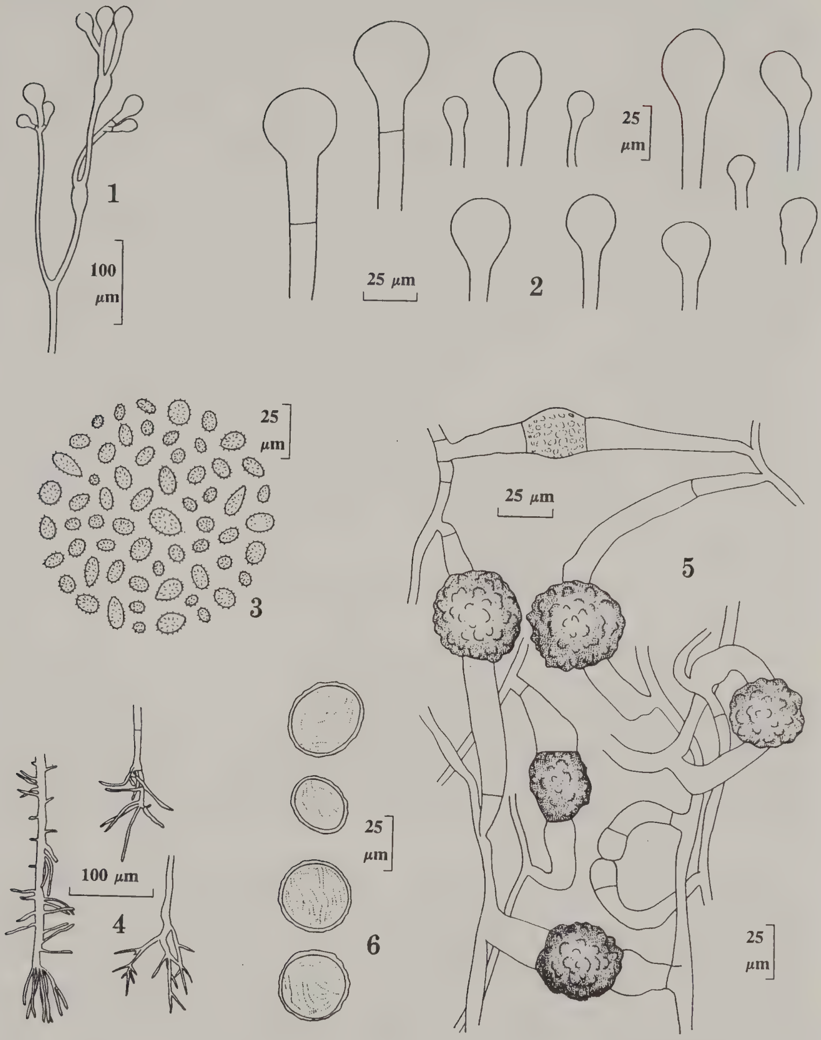
1
100 µm
25 µm
25 µm
2
25 µm
3
25 µm
5
25 µm
100 µm
4
25 µm
6
25 µm

Fig. 1b. *Cunninghamella bertholetiae*. 1. Proliferation of vesicles. 2. Vesicles of various shapes. 3. Sporangiola. 4. Rhizoids. 5. Stages of zygosporogenesis. Note that the mature zygosporangia are somewhat irregularly globose and the suspensors are very long and slender. 6. Detached zygospores. [1-4. NRRL 1380, neotype; 5, 6. Cu-19(+) × NRRL 1380(−)].

long, 9-18 μm diam., hyaline, rarely brownish. *Heterothallic.*

Maximum growth temperature: 42-43°C

DNA length of respectively ITS1, 5.8S, ITS2 and entire ITS region: 318, 154, 213, 685 bp

Strains studied: CBS 190.84 (= AS 3.4869; +, from heart of man, USA), CBS 191.84 (= AS 3.4870; −, from man, USA), **CBS 693.68** (= AS 3.5016; −, from soil, Yugoslavia; ex-Neotype of, and received as *Cunninghamella polymorpha*), NHL 2290 (= AS 3.5077; −, from man, Japan), NRRL 1379 (= AS 3.5081; +, from Brazil nuts, USA), **NRRL 1380** (= AS 3.5082; −, from Brazil nuts, USA; ex-Neotype, HMAS 80464 Neotype, newly designated in this study), NRRL 6428 (= AS 3.5091; +, origin unknown; received as *C. polymorpha*), NRRL 6436 (= AS 3.5092; +, from heart of man, USA; received as *C. elegans*), NRRL A-23796 (= AS 3.5093; −, from lung of man, locality unknown; received as *C. elegans*), Cu-19 [= AS 3.5565; +, from forest soil, Shennongjia, Hubei Prov., China; as *C. polymorpha* by Zheng & Chen (1992)], Cu-45 [= AS 3.5633; −, from rotten log, Shennongjia, Hubei Prov., China; as *C. polymorpha* by Zheng & Chen (1992)], Cu-49 [= AS 3.5569; −, from soil, Xiamen, Fujian Prov., China; as *C. polymorpha* by Zheng & Chen (1992)], Cu-50 (= AS 3.5402; −, from soil, Xiamen, Fujian Prov., China), Cu-84 [= AS 3.2021; −, from contaminated culture, Zhongguancun, Beijing, China, as *C. polymorpha* by Zheng & Chen (1992)], Cu-96 [= AS 3.5651; −, from mouldy pinecone, Xiaowutaishan, Hebei Prov., China; as *C. polymorpha* by Zheng & Chen (1992)], Cu-97 (= AS 3.5401; −, from millet seeds, Xiaowutaishan, Hebei Prov., China), Cu-98 [= AS 3.5652; −, from millet seeds, Xiaowutaishan, Hebei Prov., China; as *C. polymorpha* by Zheng & Chen (1992)], Cu-99 [= AS 3.5853; −, from medicinal herbs, Xiaowutaishan, Hebei Prov., China; as *C. polymorpha* by Zheng & Chen (1992)], Cu-101 [= AS 3.5653; −, from broad beans, Xiaowutaishan, Hebei Prov., China; as *C. polymorpha* by Zheng & Chen (1992)], Cu-102 [= AS 3.5567; −, from animal dung, Xiaowutaishan, Hebei Prov., China; as *C. polymorpha* by Zheng & Chen (1992)], Cu-139 (= AS 3.5566; from soil, Hainan, Guangdong Prov., China), Cu-140 (= AS 3.5657; from rotten carrot, the Xizang Autonomous Region, China), Cu-157 (= AS 3.5568; from soil, Yunnan Prov., China).

Dried cultures: **HMAS 80464-1—8** [Neotype, designated here, prepared from **NRRL 1380**, are being preserved in the Herbarium Mycologicum Instituti Microbiologici Academiae Sinicae (HMAS)], HMAS 80465-1—8 [prepared from Cu-19(+) × NRRL 1380(−)].

Characterization of *C. bertholletiae*: 1) colonies are 'Drab Grey' (Ridgway XLVI) to 'Mouse Grey' (Ridgway LI); 2) sporophores either terminate or do not terminate with a vesicle and directly divide into two to many branches at the apex of the main axis; 3) branches are typically long and short in the same sporophore and may repeatedly branch 1-3 times; 4) zygosporangia are smallest in diameter (24-47.5 μm) among all the other taxa and somewhat irregularly globose; 5) suspensors are the longest [reaching 80(-92) μm] but most slender (not exceeding 18 μm in diam.) of all taxa.

The relationship between *C. bertholletiae, C. elegans* and *C. polymorpha* has been very confused. *C. bertholletiae* was treated as a synonym of *C. elegans* by many authors (Lendner, 1927; Zycha, 1935; Milko & Beljakova, 1967; Samson, 1969; Zycha *et al.*, 1969; Mikawa, 1979; Baijal & Mehrotra, 1980; and Lunn & Shipton, 1983, as *C. echinulata* var. *elegans*), but considered to be distinct by others (Blakeslee *et al.,* 1921; Alcorn & Yeager, 1938; Naumov, 1939; Cutter, 1946; Moreau, 1949; Boedijn, 1958; Rayss & Borut, 1958; Weitzman & Crist, 1979, 1980; Scholer *et al.,* 1983; Weitzman, 1984; Iwatsu *et al.,* 1991; Udagawa, 1991). *C. polymorpha* was either synonimized with *C. elegans* (Lunn & Shipton, 1983) or with *C. bertholletiae* (Weitzman & Crist, 1979, 1980), but accepted as distinct (Naumov, 1939; Samson, 1969; Baijal & Mehrotra, 1980; Zheng & Chen, 1992). Weitzman & Crist (1979, 1980), in their important work of distinguishing *C. bertholletiae* from *C. elegans*, concluded that these two species could not be distinguished from one another on the basis of size and shape of the sporangiola (as 'conidia'), but according to the results of mating behavior and temperature tolerance, they further concluded that *C. polymorpha* should be treated as a synonym of *C. bertholletiae*. After studying some authentic cultures of *C. bertholletiae*, and especially after comparing the sequences of ITS2 of rDNA of *C. bertholletiae, C. polymorpha*, and *C. elegans* (Su *et al.*, 1999), the same conclusion is reached here. *C. bertholletiae* is found to be quite different from *C. elegans* but identical to *C. polymorpha* in either morphology, maximum growth temperature, or mating behavior. In *C. elegans*, the branching of sporophores is typically verticillate, and the branches are rather short and usually not long and short in the same sporophore; the two suspensors supporting a zygosporangium are very different to those of *C. bertholletiae* in morphology, they are unequal in shape, one of which is often asymmetrically inflated and ear-shaped, the length and diameter of the suspensors is only half as long but almost twice as wide as in *C. bertholletiae*. The maximum growth temperatures were found to be 42-43°C in *C. bertholletiae* and (34-)35-36°C in *C. elegans*. In mating experiment, more than 50 crosses between (+) and (−) strains of the two species have been conducted, no zygospores were formed. On the contrary, isolates formerly identified as *C. polymorpha* from various sources, including its neotype culture CBS 693.68, are found to be the same in morphology and maximum growth temperature, and zygospores were formed in crosses between many (+) and (−) strains of *C. bertholletiae*. Results of molecular studies also support the synonymy of *C. polymorpha* with *C. bertholletiae* but retain the latter as distinct from *C. elegans* (Liu *et al.*, 2001).

In 622 interspecific matings of the taxa studied, zygospores were detected in only 2 crosses, both with *C. binariae*: CBS 693.68(−) × NRRL 1375(+), NRRL A-23796(−) × NRRL 1375(+). NRRL 1375 was received as *C. bertholletiae* but its microscopic characters suggest that it should be reclassified as a new species, *C. binariae,* with NRRL 1375 as type. The maximum growth temperature of this fungus (34°C) and sequencing results of either ITS1, ITS2 or the entire ITS region (Liu *et al.*, 2001) all deviate greatly from *C. bertholletiae* (see Synoptic Key X, B.). At present it is not possible to explain why the two isolates of *C. bertholletiae* can form zygospores with the type strain of *C. binariae*. As these two taxa do not seem to be closely related in either their morphological characteristics or in their sequence analysis, they are retained as two distinct taxa.

Cunninghamella bertholletiae has been frequently reported as human pathogen causing many kinds of diseases (Kiehn *et al.*, 1979; Boyce *et al.*, 1981; McGinnis *et al.*, 1982, Nimmo *et al.*, 1988; Pena, 1988; Rex *et al.*, 1988; Anaissie *et al.*, 1989; Mostaza *et al.*, 1989; Iwatsu *et al.*, 1990; Herbrecht *et al.*, 1990; Robinson *et al.*, 1990; Zeilender *et al.*, 1990; Dernoumi, 1993; Walsh *et al.*, 1993). Weitzman & Crist (1979) stated that all of the clinical isolates studied which were previously named as *C. elegans* were *C. bertholletiae*. Scholer *et al.* (1983) also used the name *C. bertholletiae* for the pathogenic species of *Cunninghamella* reported under the name *C. elegans*.

When *C. bertholletiae* was published by Stadel in 1911, no designation of type material had been made, and since no original material is extant,

HMAS 80464-1—8, dried cultures of **NRRL 1380**, are here designated as the Neotype of *C. bertholletiae* and deposited in the Herbarium Mycologicum Instituti Microbiologici Academiae Sinicae (HMAS). Liquid nitrogen preserved cultures, lyophilised cultures, as well as cold storage cultures of NRRL 1380 are kept in the Culture Collection of the Institute of Microbiology, Academia Sinica (AS) as **AS 3.5082**.

Cunninghamella binariae R. Y. Zheng sp. nov. (Fig. 2; Pl VII: 1-7)

Coloniae in SMA floccosae, 9 cm diam. in 4 diebus ad temp. 27°C crescentes, 1-1.5 cm altae, primo albae, cito deinde dilute griseolae, griseolae, ad 'Light Mouse Grey' (Ridgway LI), inverse cremeae. *Hyphae* ramosae, nonseptatae, tarde septatae, 3.5-11.5 μm diam. *Stolones* interdum praesentes. *Rhizoidea* parca, plerumque digitaliformia. *Sporophora* erecta, recta vel recurvata, e stolonibus, rhizoideis non-oppositis, vel e hyphis aeriis enata et stolonoidea; axibus superne amplificantibus, interdum subaequis ad aequos in latitudinem per omnes partes, (8-)11-21 μm diam., hyalinis, interdum brunneolis in portione summa, frequenter cum vesica terminali, perraro dividentibus statim in ramos plures in apice; ramis primis (1-)4-10(-18), monopodialibus, pseudoverticillatis vel verticillatis in 1-2(-3) verticillis de 3-8, typice binis, et enatis de communi basi bulbosa vel non-bulbosa, simplicibus vel simpodice et 1-2(-3) ramosis, perbrevibus ad longos, 9-115(-405) μm in longitudinem, 5-9.5 μm in latitudinem, cum vesica apicali praeditis in ramis fertilibus; ramis sterilibus aliquando praesentibus. *Septa* in sporophoro absentia vel praesentia, frequenter formata in basi ramorum. *Vesicae* globosae, subglobosae ad ovoideas, interdum irregulares, in axibus 18.5-32(-40) μm diam., in ramis lateralibus (8-)13.5-30 μm diam., plerumque brunneolae, generaliter fertiles et supra superficies suas totas pedicellos numerosos efformantes. *Pedicelli* 2.5-3.5(-6) μm longi. *Sporangiola* in pedicellis e vesicae enata, ovoidea ad ellipsoidea et 7-14.5(-20) × 6.5-11(-14.5) μm, globosa et 5.5-12.5 μm diam., lacrimoidea et 9-20(-32.5) × 7-14.5(-20) μm, hyalina vel subbrunneola, spinosa, cum spinis confertis et modice longis, monospora. *Sporangiosporae* sine spinis sed tuberculatae, similes in forma et magnitudine sporangiolis quae eas gerentia. *Chlamydosporae* absentes. *Zygosporae* ignotae.

HOLOTYPUS **HMAS 79279-1—7**: cultura exsiccata ex **NRRL 1375** (= AS 3.5078; instar *C. bertholletiae* accepta), Blakeslee's Collection, in Herbarium Mycologicum Instituti Microbiologici Academiae Sinicae (HMAS) conservata.

Colonies on SMA floccose, reaching 9 cm diam. in 4 days at 27°C, about 1-1.5 cm high, at first white, soon becoming light grey, grey, to 'Light Mouse Grey' (Ridgway LI), reverse cream. *Hyphae* branching, nonseptate when young, septate in age, 3.5-11.5 μm diam. *Stolons* sometimes present. *Rhizoids* scanty, mostly finger-like. *Sporophores* erect, straight, or recumbent, arising from stolons, with non-opposite rhizoids, or directly arising from aerial hyphae and stolon-like; main axes of sporophores enlarging upwards, sometimes subequal to equal in width throughout, (8-)11-21 μm diam., hyaline, sometimes brownish at the uppermost part, often terminated with a vesicle, very rarely dividing directly into several branches at the apex; primary branches (1-)4-10(-18), monopodial, pseudoverticillate or verticillate in 1-2(-3) whorls of 3-8, typically in pairs and arising from a common base which may be bulbous or not, simple or sympodially and repeatedly branching 1-2(-3) times, very short to long, 9 -115(-405) μm long, 5-9.5 μm wide, terminating with a vesicle in the fertile branches, sterile branches occasional. *Septa* in sporophores absent or present, often formed at the base of the branches. *Vesicles* globose, subglobose to ovoid, sometimes irregular, axial vesicles 18.5-32(-40) μm diam., lateral ones (8-)13.5-30 μm diam., mostly brownish, giving rise to numerous pedicels over their entire surfaces. *Pedicels* 2.5-3.5(-6) μm long. *Sporangiola* borne on pedicels on vesicles, ovoid to ellipsoid and 7-14.5(-20) × 6.5-11(-14.5) μm, globose and 5.5-12.5 μm diam., lacrymoid and 9-20(-32.5) × 7-14.5(-20) μm, hyaline or brownish, with thick and moderately long spines, monosporous. *Sporangiospores* detachable, but usually remaining within the sporangiola, spineless, tuberculate, hyaline, similar in shape and size to the sporangiola bearing them. *Chlamydospores* absent. *Zygospores* unknown. Probably *heterothallic*.

Maximum growth temperature: 34°C

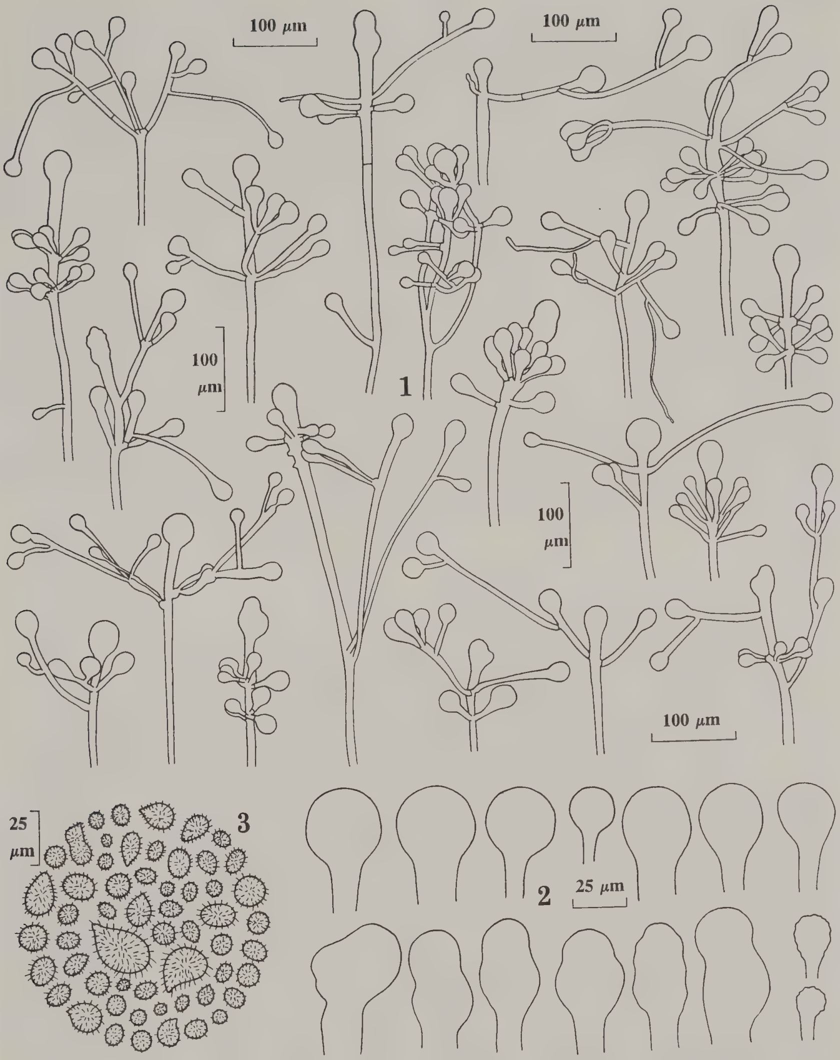

Fig. 2. *Cunninghamella binariae* 1. Terminal portions of sporophores showing characteristic branching patterns. Note that the sporophores often broaden upwards and usually terminate with a vesicle, the branches are typically long and short in the same sporophore and in pairs, remaining simple or repeatedly branching 1-3 times; sterile branches sometimes present. 2. Vesicles which are globose, subglobose, ovoid, or irregularly shaped. 3. Sporangiola. [1-3. NRRL 1375, type].

DNA length of respectively ITS1, 5.8S, ITS2, and entire ITS region: 281, 154, 205, 640 bp

Strain studied: **NRRL 1375** (= AS 3.5078; +, received as *C. bertholletiae*, Blakeslee's Collection).

Dried cultures: **HMAS 79279-1—7** [Holotype, prepared from **NRRL 1375**, are being preserved in the Herbarium Mycologicum Instituti Microbiologici Academiae Sinicae (HMAS)].

Characterization of *C. binariae*: 1) colonies are 'Light Mouse Grey' (Ridgway LI); 2) main axes of sporophores are often enlarged upwards; 3) branches are typically long and short in the same sporophore and may repeatedly branch 1-3 times; 4) branches are typically in pairs and arise from a common base which may be bulbous or not; 5) sterile branches occasionally present; 6) sizes of sporangiola vary greatly; and 7) a tendency of forming zygospores with *C. bertholletiae* though the two taxa are genetically remote as revealed by data resulting from sequencing of the ITS region of rDNA.

The species most closely related to *C. binariae* is doubtless *C. bertholletiae*. As seen in the Synoptic Key and the Dichotomous Key, both taxa share many common characteristics and the type and only strain of *C. binariae*, NRRL 1375, can even mate and form zygospores with 2 of the strains of *C. bertholletiae*, CBS 693.68 and NRRL A-23796; on the other hand, there are still many differences sufficient for separating them. Excepting morphological differences, the maximum growth temperature differs significantly, and most important of all, results of sequencing of the rDNA ITS region clearly indicate that it is not conspecific with either *C. bertholletiae* or any other known species of the same genus (Liu *et al.*, 2001).

Cunninghamella blakesleeana Lendn., Bull. Soc. Bot. Genève 19: 234. 1927. (Fig. 3; Pl. I: 1, 2; Pl. IV: 2; Pl. V: 3, 4)

≡ *Cunninghamella* "A" Blakeslee, Cartledge & Welch, Bot. Gaz. 72: 185. 1921.

= *Cunninghamella elegans* sensu auct.: Zycha, Linnemann & Siepmann, Mucorales. p.148. 1969. p.p.; non Lendner, Bull. Herb. Boissier 7: 250. 1907.

≡ *Cunninghamella echinulata* var. *elegans* (Lendn.) Lunn & Shipton, Trans. Brits. Mycol. Soc. 81: 312. 1983. p.p.

Colonies on SMA floccose, reaching 9 cm diam. in 4 or 5 days at 28°C, about 1 cm high or higher, at first white, becoming yellowish, then greyish-yellow, reverse cream. *Hyphae* branching, nonseptate when young, septate in age, 2-13 μm diam. *Stolons* sometimes present. *Rhizoids* quite abundant, root-like or finger-like, simple or repeatedly branched, long or short. *Sporophores* erect, straight or recumbent, arising from stolons, sometimes opposite rhizoids, or directly from aerial hyphae and stolon-like; main axes of sporophores usually equal in width throughout, (4.5-)6-15.5(-18.5) μm diam., all terminated with a vesicle, simple or branched; branches 1-8, single, in pairs, or in 1(-2) whorls of 3-5, typically short and not exceeding 60 μm in length, but very rarely may reaching a length of 180 μm or more, branches almost exclusively simple and not giving rise to secondary ones, all terminated with a vesicle. *Septa* in sporophores usually absent, rarely formed at the base of the branches. *Vesicles* quite regular in shape, globose, subglobose to broadly ovoid, smooth, hyaline, terminal ones on main axes 13.5-45 μm diam., those on the branches mostly smaller than the terminal ones and 11-36.5 μm diam., rarely even larger and reaching a diameter of 52 μm, proliferation of vesicles sometimes occurring, giving rise to numerous pedicels over their entire surfaces. *Pedicels* 2.5-3.5(-6) μm long. *Sporangiola* borne on pedicels on vesicles, ovoid, ellipsoid or globose, with or without a pointed end, predominantly globose after 4-5 days, 8.5-22(-32) × 8.5-16.5 μm or 5.5-14.5(-17.5) μm diam., hyaline, very shortly and sparsely echinulate, monosporous. *Sporangiospores* detachable, but usually remaining within the sporangiola, spineless,

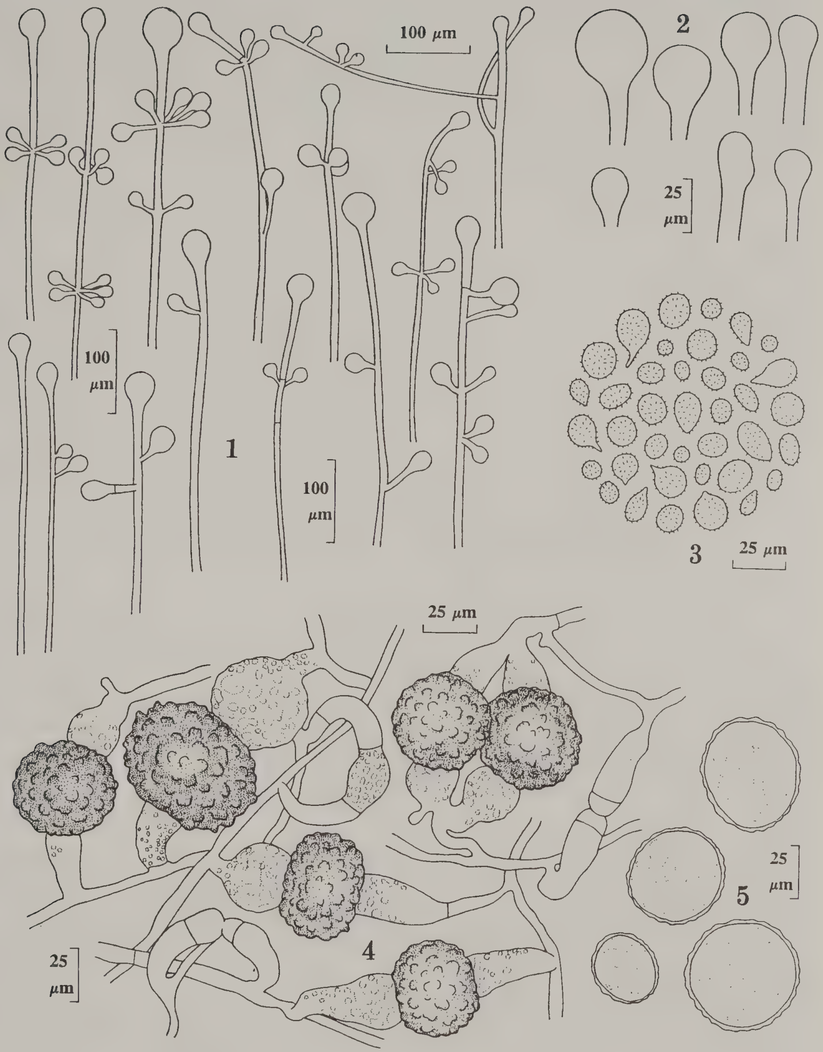

Fig. 3. *Cunninghamella blakesleeana*. 1. Terminal portions of sporophores showing characteristic branching patterns. Note that the branches of the sporophore are usually few in number, verticillate or monopodial, typically short and of approximate length in the same sporophore, remaining simple or branched; also note that some of the lateral vesicles may become larger in diameter than the axial ones. 2. Vesicles. 3. Sporangiola. 4. Various stages of zygosporogenesis. Note that the mature zygosporangia are often depressed-globose, the two suspensors of a zygosporangium are heavily incrusted and typically unequal in shape, one of which often strongly inflates into a globose shape. 5. Detached zygospores. [1-3. CBS 133.27, type; 4, 5. CBS 133.27(+) × Cu-53(−)].

tuberculate, hyaline, similar in shape and size to the sporangiola bearing them. *Chlamydospores* absent. *Zygosporangia* depressed-globose, rarely globose, 28-73.5 μm diam., reddish brown when mature, warted, with blunt projections, monosporous. *Zygospores* ellipsoid or subglobose, 24-70 μm diam., outer wall thin, crenulate, with indistinct ridges, hyaline. *Suspensors* mostly unequal in shape and size, typically one symmetrically inflated and one not inflated, rarely equal, with both suspensors inflated or not inflated, in either case, all suspensors attenuated and not exceeding 8 μm at the very base, 12.5-54 μm long and 12.5-45 μm diam., septa absent, generally heavily incrusted and orange to brownish-orange. *Heterothallic.*

Maximum growth temperature: (36-)37-38°C

DNA length of respectively ITS1, 5.8S, ITS2, and entire ITS region: 283, 155, 220, 658 bp

Strains studied: **CBS 133.27** (= AS 3.5010; +, from Brazil nuts, USA; ex-Type), IMI 53585 (= AS 3.5064; +, substratum and origin unknown), Cu-53 (= AS 3.5636; −, from soil, Xiamen, Fujian Prov., China), Cu-54 (= AS 3.5637; +, from soil, Xiamen, Fujian Prov., China), Cu-63 (= AS 3.5641; +, from soil, Fuzhou, Fujian Prov., China), Cu-80 (= AS 3.2016; +, from soil, Hefei, Anhui Prov., China), Cu-81 (= AS 3.2017; −, from soil of a sweet potato field, Hainan, Guangdong Prov., China), Cu-82 (= AS 3.2018; −, from soil, Ningming, Guangxi Prov., China), Cu-83 (= AS 3.3401; +, from soil, Hefei, Anhui Prov., China), Cu-89(= AS 3.153; +, substratum unknown, Dalian, Liaoning Prov., China), Cu-143 (= AS 3.5658; from soil of a flower nursery, Kowloon, Hong Kong, China), Cu-144 (= AS 3.5659; from rotten mushroom, Beijing, China), Cu-166 (= AS 3.5660; from soil of a bamboo forest, Baoshan, Yunnan Prov., China), Cu-181 (= AS 3.5392; −, from soil, Guilin, Guangxi Prov., China), Cu-200 (= AS 3.5395; from faded flower of a pumpkin, Xishuangbanna, Yunnan Prov., China).

Dried cultures: **HMAS 80466-1—7** (Isotype, prepared from **CBS 133.27**), HMAS 80467-1—8 [prepared from CBS 133.27(+) × Cu-53(−)].

Characterization of *C. blakesleeana*: 1) colonies have a very pale colour which is often white then yellowish, becoming pale greyish-yellow when old; 2) sporophore branches are usually few in number [0-4(-8)], verticillate or monopodial, typically short and not exceeding 60 μm in length, remaining simple and not repeatedly branched; 3) lateral vesicles may become larger in diameter than the axial ones; 4) length of the ovoid or lacrymoid sporangiola is the largest (reaching 32 μm) of all taxa in the genus; 5) diameter of the depressed-globose zygosporangia is the largest of all (reaching 73 μm); 6) the two zygosporangium suspensors are heavily incrusted and orange, typically unequal in shape, one of which often strongly inflates into a globose shape and reaches a diameter of 45 μm.

Most people accept *C. blakesleeana* except Zycha *et al.* (1969) and Lunn & Shipton (1983) who treated it as a synonym of *C. elegans* (as *C. echinulata* var. *elegans* by Lunn & Shipton). The reasons for putting *C. blakesleeana* into synonymy with *C. elegans* by Lunn & Shipton (1983) are as follows: the colony colour used to separate *C. blakesleeana* and *C. elegans* was thought to be medium dependent since they have encountered a grey, strongly mating isolate of *C. blakesleeana* (IMI 54601); three crosses between two isolates of *C. blakesleeana* and two isolates of *C. elegans* produced zygospores, and zygospores were morphologically similar in *C. blakesleeana* × *C. blakesleeana* and *C. elegans* × *C. elegans* crosses. The two isolates of one of the three crosses which were said to be able to form zygospores between these two species, *C. blakesleeana* IMI 53585 and *C. elegans* IMI 198488 were both marked by Lunn & Shipton as (+) in their mating type in Fig. 1 of their paper (Lunn & Shipton, 1983). Another cross, *C. blakesleeana* IMI 53585 (+) × *C. elegans* IMI 120683ii [an equivalent of CBS 481.66 (−)], which was also said to produce zygospores, was found here to be not reproductive. The name of the isolate IMI 120683ii, according to our reidentification, should be *C. phaeospora* and not *C. elegans*. In the many other crosses between *C. blakesleeana* and *C. elegans* made here, none was found to be successful.

Results here suggest that *C. blakesleeana* and *C. elegans* should be maintained as distinct. Even if the colony colour is considered unreliable (in fact it is quite reliable!), there are still many other morphological differences worthy of consideration for distinguishing them. The sporangiola dimension is always much larger in *C. blakelseeana* than in *C. elegans* (compare Pl. IV: 1 & 7). The zygosporic morphology is especially dissimilar: the zygosporangia are mainly depressed-globose, the inflated suspensor is symmetrical and globose, all parts including the diameter of the zygosporangia and zygospores, diameter and length of the suspensors are larger in the former; while the zygosporangia are globose to subglobose, the inflated suspensor is unsymmetrical and typically ear-shaped, all parts mentioned above are smaller in the latter (compare Pl. V: 3 and Pl. VI: 1). Furthermore, the maximum growth temperature is (36-)37-38 and (34-)35-36°C in *C. blakesleeana* and *C. elegans* respectively, and the genetic distance between the ex-type cultures of these two taxa reaches 0.1734 (Liu *et al.*, 2001), indicating that they are not conspecific.

Cunninghamella blakesleeana seems to have strongest mating ability as compared to the other taxa in the genus. In intraspecific mating, all (+) strains are able to form zygospores with almost all of the (−) strains. In interspecific mating, many strains of this species can form gametangia with many strains of the other species of opposite mating type.

Cunninghamella clavata R. Y. Zheng & G. Q. Chen, Mycotaxon 69: 189. 1998. (Fig. 4; Pl III: 4-6; Pl. IV: 3).

Colonies on SMA floccose, reaching 9 cm diam. in 5 or 6 days at 28°C, about 1-1.5 cm high, white for 5-7 days, becoming pale greyish and remaining so, reverse cream. *Hyphae* branching, non-septate when young, occasionally septate in age, 3.5-9.5(-12.5) μm diam. *Stolons* usually present. *Rhizoids* abundant, long or short, simple or branched. *Sporophores* erect, straight or recumbent, arising from stolons, sometimes opposite rhizoids, or directly from aerial hyphae and stolon-like, hyaline, smooth; main axis rarely simple, usually branching, equal in width throughout, 5.5-13.5(-18) μm diam., sometimes slightly enlarging at the uppermost part, terminating in a vesicle, later septate under or above the branches or at their base; primary branches 1-4, single, in pairs, or 3-4 arranged pseudoverticillately, never verticillate, remaining simple or repeatedly branching 1-3(-7) times, subsidiary branches arising typically at right angles and just beneath the vesicle of the former branch, variable in length, (35-)100-800 μm long, 4.5-10.5 μm wide, straight to slightly curved, terminating in a vesicle. *Vesicles* typically clavate, axial vesicles very rarely subovoid to irregular, (9-)18-30(-42) μm diam., lateral vesicles (5.5-)7-18.5(-31) μm diam., hyaline, with occasional proliferation. *Sporangiola* borne on pedicels measuring 2.5-9(-11) μm in length, on the entire or upperhalf surface of the vesicles, strictly globose, 9.5-20(-27) μm diam., pale brown, spinose, with short, thick spines. *Sporangiospores* detachable, but usually remaining within the sporangiola, spineless, tuberculate, hyaline, similar in shape and size to the sporangiola bearing them. *Chlamydospores* absent. *Zygospores* unknown. Probably *heterothallic*.

Maximum growth temperature: 34-35°C

DNA length of respectively ITS1, 5.8S, ITS2, and entire ITS region: 328, 154, 199, 681 bp

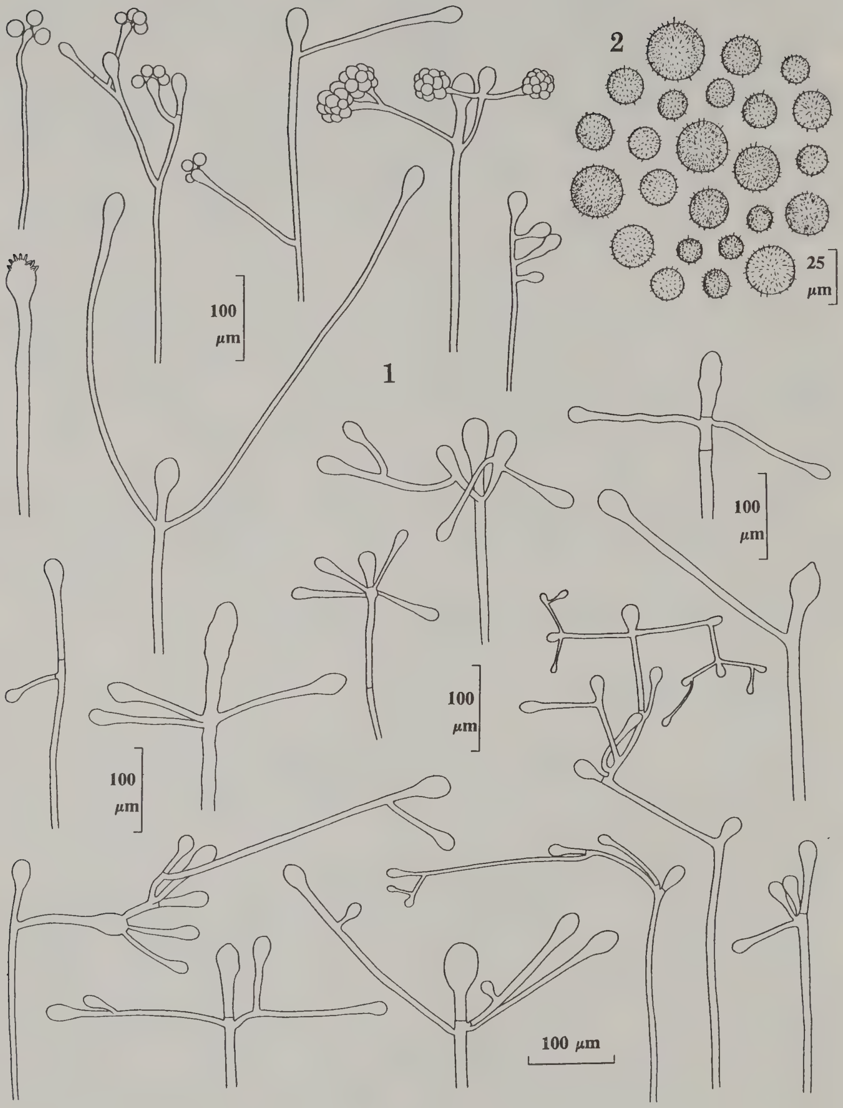

Fig. 4. *Cunninghamella clavata*. 1. Terminal portions of sporophores showing characteristic branch patterns. Note that the primary branches may remain simple or repeatedly branch 1-3(-7) times, with subsidiary branches arising typically at right angles and just beneath the vesicle of the former branch; vesicles are clavate in shape. 2. Strictly globose sporangiola. [1, 2. Cu-15 (=AS 3.4809), type].

Strains studied: **Cu-15** (= AS 3.4809; +, from faded flower, Guiyang, Guizhou Prov., China; ex-Type), Cu-185 (= AS 3.5004; +, from soil of a riverbank, Guiyang, Guizhou, China; ex-Paratype), Cu-202 (= AS 3.5005; +, from soil of a vegetable garden, Xishuangbanna, Yunnan Prov., China; ex-Paratype).

Dried cultures: **HMAS 59495-1—9** [Holotype, prepared from **Cu-15** (= AS 3.4809)], HMAS 59496 (Isotype, also prepared from Cu-15), HMAS 74525 [Paratype, prepared from Cu-185 (= AS 3.5004)], HMAS 74526 [Paratype, prepared from Cu-202 (= AS 3.5005)].

Characterization of *C. clavata*: 1) colonies are white in the first 5-7 days, becoming pale greyish in age and remaining so afterwards; 2) occasionally two types of sporophores, the longer type and the shorter type, can be seen; 3) sporangiola are strictly globose; 4) vesicles are clavata; 5) the branching type of the sporophores is unique in repeatedly branching 1-3(-7) times, with subsidiary branches arising typically at right angles and just beneath the vesicle of the former branch; 6) pedicels are very long as compared with the other taxa in the same genus and may reach 11 μm in length.

Morphological distinctions among *C. clavata* and related taxa have already been discussed by Zheng & Chen (1998). Molecular distinctions among *C. clavata* and the other taxa in *Cunninghamella* are just as evident. For example, lengths of ITS1 and ITS2 regions of ribosomal RNA gene of *C. clavata* are respectively the longest and shortest among all the taxa tested (see Table 2 of Liu *et al.*, 2001); the genetic distances between *C. clavata* and any of the *Cunninghamella* taxa are from 0.2380 to 0.6685 (see Table 3 of Liu *et al.*, 2001), revealing that this species is phylogenetically different from the others and is recognized as distinct.

All of the three strains hitherto found are (+) in their mating type. When mated with 56 representatives or strong mating pairs of the other 11 taxa of *Cunninghamella*, Cu-15 and Cu-202 reacted weakly and formed gametangia each with two (−) strains only, while Cu-185 formed gametangia with nearly all of the (−) strains of almost all of the taxa tested. However, none of the crosses resulted in zygospore formation (Zheng & Chen, 1998).

Cunninghamella echinulata (Thaxt.) Thaxt. ex Blakeslee, Bot. Gaz. 40: 161. 1905. var. ***echinulata*** (Fig. 5; Pl. II: 1, 2; Pl. IV: 4; Pl. V: 5, 6, 9, 10)

≡ *Oedocephalum echinulatum* Thaxt., Bot. Gaz. 16: 17. 1891.

≡ *Cunninghamella echinulata* (Thaxt.) Thaxt., Rhodora 5: 98. 1903. nom. inval.

= *Cunninghamella africana* Matr., Ann. Mycol. 1: 47. 1903.

Colonies on SMA floccose, very rarely granulate, reaching 9 cm diam. in 6 days at 28°C, about 0.5-1 cm high, at first white, from the third or fourth day light 'Avellaneous'(Ridgway XL) to 'Light Drab' (Ridgway XLVI) at the central portion, becoming greyish-brown in the whole colony afterwards, reverse cream. *Hyphae* branching, nonseptate when young, septate in age, 2.5-10 μm diam. *Stolons* sometimes present. *Rhizoids* frequent, simple or branching, long or short. *Sporophores* erect, straight or recumbent, arising from stolons, sometimes opposite rhizoids, or directly from aerial hyphae and stolon-like, often of two intergrading kinds, the typical longer type and the shorter type; main axes of the sporophores all terminting in a vesicle, often equal in width throughout, rarely and slightly broadening upwards, 5.5-15(-18.5) μm diam., branching profusely in the longer type and not branching or with only one simple branch in the shorter type; branches on the longer sporophores 0-4(-10), single, in pairs, or rarely pseudoverticillate, true verticillate branches usually absent, simple or repeatedly branching 1-2(-3) times, variable in length, 20-150(-250) μm long. *Septa* in sporophores absent or present, usually at the place of branching when formed. *Vesicles* quite regular in the longer type of sporophores, mostly globose to subglobose, terminal vesicles (12.5-)17.5-32(-41.5) μm diam., lateral vesicles (8.5-)11-22.5(-27.5) μm diam., smooth, usually hyaline, very rarely with a pale brownish tint, vesicles on longer type of sporophores giving rise over the entire surface to numerous pedicels, vesicles on the shorter type of sporophores clavate to subclavate, forming pedicels only at the upper part, proliferation of vesicles rare. *Pedicels* 2.5-4(-6.5) μm long. *Sporangiola* borne on pedicels on vesicles and of two kinds: either hyaline or subhyaline, globose to broadly ellipsoid or ovoid and bluntly pointed at one end, 8.5-17.5(-21.5) × 7-13.5(-15.5) μm or 8-14.5 μm diam., or dark giant sporangiola exclusively globose, 8.5-19.5(-27) μm diam., all evidently echinulate, with long thick spines and monosporous. *Sporangiospores* detachable, but usually remaining within the sporangiola, spineless, tuberculate, hyaline, similar in shape and size to the sporangiola bearing them. *Chlamydospores* absent. *Zygosporangia* globose to subglobose, 24-53.5 μm diam., dark brown when mature, with pointed wart-like projections. *Zygospores* mainly globose, rarely broadly ellipsoid, 21-46.5 μm diam., outer wall slightly crenulate to more or less smooth, with indistinct ridges, hyaline. *Suspensors* mostly equal and not inflated, 18-35.5 μm long and 9-29.5 μm diam., typically remaining straight, sometimes broadening towards the base, rarely constricted at the base, with or without a septum, usually not incrusted and hyaline, rarely slightly incrusted and brownish. *Heterothallic.*

Maximum growth temperature: (37-)39-42°C

DNA length of respectively ITS1, 5.8S, ITS2, and entire ITS region: 228, 154, 419, 801 bp

Strains studied: **CBS 156.28** (= AS 3.4873; +, from air, USA; ex-Neotype), CBS 694.68 [= AS 3.4879; +, substratum and origin unknown; according to Samson (1969), this strain is equivalent to NRRL A-15750 and was received as '*Cunninghamella japonica*', sent by J. N. Rai, India, to C. W. Hesseltine as *Cunninghamella* sp. nov.], IMI 198484 [= AS 3.4830; −, from soil, Australia; according to Lunn & Shipton (1983), this strain was received as *C. phaeospora*], MUCL 38718 (= AS 3.5771; substratum and origin unknown), Cu-16 (= AS 3.5620; +, from animal dung, Shennongjia, Hubei Prov., China), Cu-24 (= AS 3.5623; +, from soil under grasses, Nanjing, Jiangsu Prov., China), Cu-33 (= AS 3.5627; −, from faded flower, Zhongguancun, Beijing, China), Cu-38 (= AS 3.5630; −, from soil under rotten grasses, Guiyang, Guizhou Prov., China), Cu-41 (= AS 3.5632; +, from forest soil, Yanqing, Beijing, China), Cu-62 (= AS 3.5640; −, from soil, Shanghai, China), Cu-71 (= AS 3.5643; +, from soil, Hangzhou, Zhejiang Prov., China), Cu-90 (= AS 3.5563; from field soil, Xiaowutaishan, Hebei Prov., China), Cu-91 (= AS 3.5648; +, from grassland soil, Xiaowutaishan, Hebei Prov., China), Cu-92 (from cow dung, Xiaowutaishan, Hebei Prov., China), Cu-93 (= AS 3.5514; from corn field soil, Xiaowutaishan, Hebei Prov., China), Cu-94 (−, from vegetable garden soil, Xiaowutaishan, Hebei Prov., China), Cu-142 (from dried celery, Xian, Shaanxi Prov., China), Cu-153 (= AS 3.5515; from rotten mushroom, Beijing, China), Cu-159 (from mouldy fruit of eggplant, Mangshi, Yunnan Prov., China), Cu-160 (= AS 3. 5516; from corn field soil, Xiaguan, Yunnan Prov., China), Cu-161 (= AS 3.5389; from cave soil, Ruoergai Prairie, Sichuan Prov., China), Cu-171 (= AS 3.5391; from mouldy eggplant, Mangshi, Yunnan Prov., China), Cu-172 (= AS 5517; from soil, Lazikou, Gansu Prov., China), Cu-178 (= AS 3.5518; +, from soil, Lanzhou, Gansu Prov., China), Cu-196 (= AS 3.5393; from soil under rotten leaves, Jiange, Gansu Prov., China), Cu-204 (= AS 3.5519; from soil under a shrub, Chengdu, Sichuan Prov., China), Cu-224 (= AS 3.5520; from soil, locality unknown, China), Cu-227 (= AS 3.5399; from orchard soil, Kuerie, Xinjiang Uygur Autonomous Region, China), Cu-228 (= AS 3.5400; from bamboo forest soil, Zhuhai, Guangdong Prov., China).

Dried cultures: **HMAS 80486-1—8** (Isotype, prepared from **CBS 156.28**), HMAS 80487-1—8 [prepared from CBS 156.28(+) × Cu-38(−)].

Characterization of *C. echinulata* var. *echinulata*: 1) colonies are cream to brownish cream ('Avellaneous'), often cottony and very rarely somewhat powdery in appearance; 2) two different kinds of fruiting structures, the longer and shorter types of sporophores present; 3) primary branches of the sporophores are monopodial or pseudoverticillate but never verticillate, may repeatedly branch, branches are long and short in the same sporophore; 4) two kinds of sporangiola, the ordinary subhyaline ones in young cultures and the dark giant sporangiola in old cultures are formed; 5) the two suspensors supporting zygosporangium are

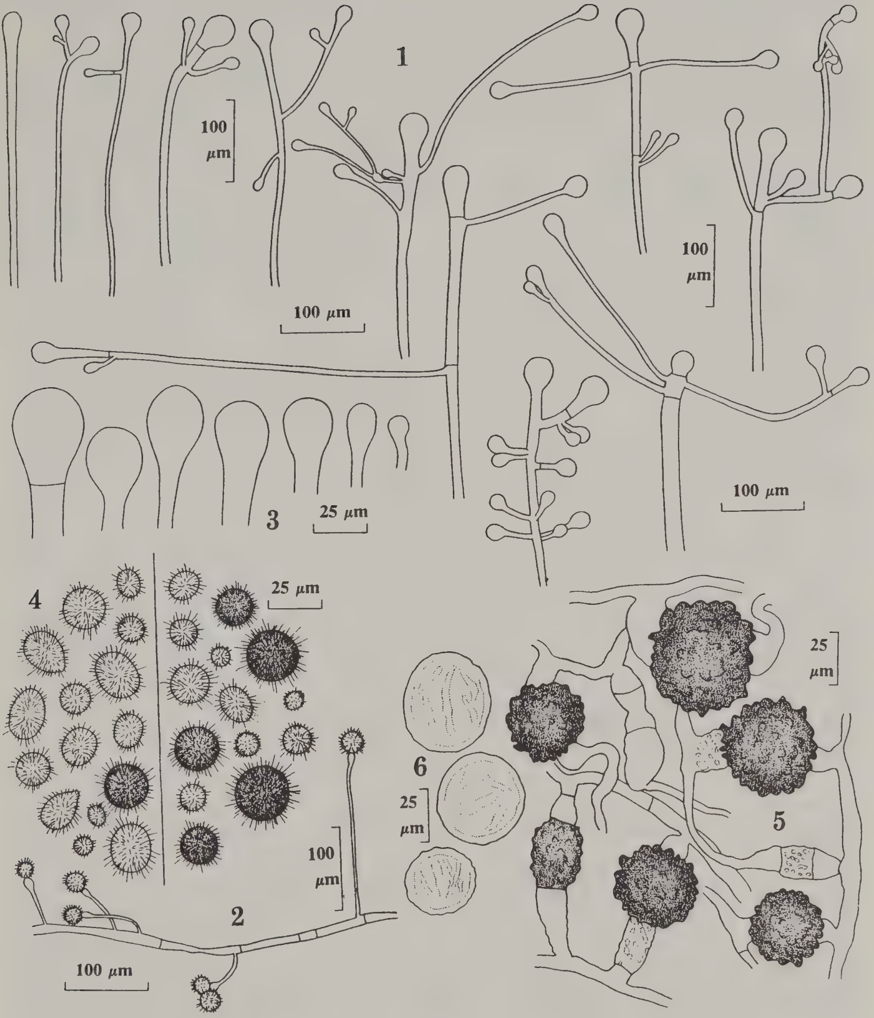

Fig. 5. *Cunninghamella echinulata* var. *echinulata*. 1. Terminal portions of the longer type sporophores showing characteristic branching patterns. Note that the primary branches are often monopodial, rarely pseudoverticillate, typically long and short in the same sporophore, and may repeatedly branch 1-2(-3) times. 2. Five shorter type sporophores formed on a hypha. 3. Vesicles of various shapes. 4. Sporangiola formed at the 3rd day (left) and 6th day (right), note the dark giant sporangiola interspersed. 5. Various stages of zygosporogenesis. Note that the two suspensors of a mature zygosporangium are equal in shape, usually not inflated, and typically remaining straight and not constricted at the base. 6. Detached zygospores. [1-4. CBS 156.28, neotype; 5, 6. CBS 156.28(+) × Cu-38(−)].

equal in shape, usually not inflated, and typically remaining straight and not constricted at the base.

Being the type species of the genus, *C. echinulata* is accepted by almost all authors except Naumov (1939) who preferred to use *C. africana* Matr. instead of the correct name. For many years, *C. echinulata* has been recognized sensu stricto by treating *C. bainieri* (= *C. echinulata* var. *verticillata*) as a distinct species (Naumov, 1939; Cutter, 1946; Nicot-Toulouse, 1950; Rayss & Borut, 1958; Zycha *et al.*, 1969; Baijal & Mehrotra, 1980) or sensu lato by synonymizing *C. bainieri* (Milko & Beljakova, 1967; Samson, 1969; Milko, 1974; Lunn & Shipton, 1983). Those who retained *C. bainieri* based their treatment on the followings: first, branching type of sporophores is cymose or irregular in *C. echinulata*, and verticillate or pseudoverticillate in *C. bainieri*; second, dark giant sporangiola (as 'giant conidia' by many authors) are not formed in the former and formed in the latter; third, growth at 40°C occurs in the former and does not occur in the latter. Others thought that either all of the above mentioned kinds of branching type, formation of dark giant sporangiola, or growth at 40°C can be found in both species, and since the two species are able to produce zygospores when mated to each other, they should be treated as conspecific.

Zheng & Chen (1996) inspite of agreeing that many strains of both *C. echinulata* and *C. bainieri* can form dark giant sporangiola, grow well at 40°C, and produce zygospores in the presence of (+) and (−) strains, still considered the two taxa to be distinguishable and published them as two different varieties: *C. echinulata* var. *echinulata* and *C. echinulata* var. *verticillata*. The epithet '*verticillata*' was adopted based on the name *C. blakesleeana* var. *verticillata* (F. S. Paine) Baijal & B. S. Mehrotra (basionym *C. verticillata* F. S. Paine), which was considered to be synonymous with *C. bainieri*.

Besides *C. echinulata* var. *verticillata*, we also accomodate two other varieties, *C. echinulata* var. *antarctica* comb. nov. (basionym: *C. antarctica* Caretta & Piont.) and *C. echinulata* var. *nodosa* under this species. Two more names have been treated as varieties of *C. echinulata*: *C. echinulata* var. *indica* (Baijal & B. S. Mehrotra, 1980) seems to bear strong resemblance to *C. clavata* (see Zheng & Chen, 1998 for the details) rather than to *C. echinulata*. The holotype of *C. echinulata* var. *indica* has been lost and it has not been re-collected. The taxonomic position of this fungus can be determined only after new material is found and restudied. *C. echinulata* var. *elegans* (Lendn.) Lunn & Shipton (1983) is a reduction of *C. elegans* to this name. In the classification proposed here, *C. echinulata* consists of four varieties: var. *echinulata*, var. *antarctica*, var. *nodosa*, and var. *verticillata*.

Like *C. blakesleeana*, *C. echinulata* var. *echinulata* has very strong mating ability, forming zygospores easily with the opposite mating type partners of either the same variety, var. *echinulata,* or the other variety, var. *verticillata*, though none of the strains of both these varieties respond to *C. echinulata* var. *antarctica* or *C. echinulata* var. *nodosa*.

Cunninghamella echinulata var. ***antarctica*** (Caretta & Piont.) R. Y. Zheng & G. Q. Chen, comb. nov. (Fig. 6; Pl. II: 3-5; Pl. IV: 5)

≡ *Cunninghamella antarctica* Caretta & Piont., Sabouraudia 15: 6. 1977. (basionym)

= *Cunninghamella echinulata* var. *echinulata* sensu auct.: Lunn & Shipton, Trans. Brit. Mycol. Soc. 81: 311. 1983 p.p.; non Blakeslee, Bot. Gaz. 40: 161. 1905.

Colonies on SMA at first floccose, soon becoming granulate, reaching 9 cm diam. in 5 or 6 days at 28°C, 2-3 mm high, white at first, soon becoming pale 'Avellaneous' (Ridgway XL), reverse cream. *Hyphae* branching, nonseptate when young, septate in age, (4.5-)7-14.5 μm diam. *Stolons* usually present, hyaline, generally with many septa. *Rhizoids* abundant, usually very long and mycelium-like. *Sporophores* erect, straight or recumbent, arising from stolons, or directly from aerial hyphae and stolon-like, with two kinds of structures, but the shorter type is rare and seldom seen; main axes of sporophores usually branching and enlarging upwards or unequal in width throughout, (7.5-)12.5-19.5(-24.5) μm diam., hyaline, sometimes pale brown at the uppermost part, smooth, nonseptate or septate at the place of branching, terminating in a vesicle or dividing into 2-many branches at the apices; primary branches 1-9, single, in pairs, or 3-6 verticillate or pseudoverticillate, remaining simple or sympodially and repeatedly branching 1-2(-3) times, typically 2 branches seen arising from a common bulbous base, very short to very long, 14.5-255(-500) μm in length, flaccid when long, all terminating with a vesicle. *Septa* in sporophores absent or present, usually at the place of branching or at the base of the branches when formed. *Vesicles* mostly globose to subglobose, rarely ovoid, axial ones (17-)22-41.5(-61.5) μm diam., hyaline to brownish, lateral ones (8.5-)14.5-27(-34.5) μm diam., hyaline, giving rise to numerous pedicels over their entire surfaces. *Pedicels* 2-3(-7.5) μm long. *Sporangiola* borne on pedicels on vesicles, mostly spherical and 9.5-16 μm diam., the others broadly to narrowly ovoid, obtuse or pointed at one end, 11-14.5(-21.5) × 8.5-12.5(-15) μm, hyaline, with thick and moderately long spines, monosporous, a few dark, globose, giant sporangiola reaching 20 μm diam. sometimes present in older cultures. *Sporangiospores* detachable, but usually remaining within the sporangiola, spineless, tuberculate, hyaline, similar in shape and size to the sporangiola bearing them. *Chlamydospores* not seen. *Zygospores* unknown. Probably *heterothallic*.

Maximum growth temperature: 41-42°C

DNA length of respectively ITS1, 5.8S, ITS2, and entire ITS region: 236, 154, 420, 810 bp

Strain studied: **CBS 545.75** (= AS 3.4867; mating type unknown, from hair baited soil, the Antarctic Continent; ex-Type of *C. antarctica* Carretta & Piont.).

Dried culture: **HMAS 80488-1—8** (Isotype, prepared from **CBS 545.75**).

Characterization of *C. echinulata* var. *antarctica*: 1) colonies are 'Avellaneous' and powdery in appearance; 2) two kinds of fruiting structures present, though the shorter type is merely occasional; 3) sporophores are either terminated with a vesicle or not terminated and directly divide into two to many branches at the apex of the main axes; 4) main axes of sporophores are frequently enlarging upwards; 5) branches are typically long and short in the same sporophore and may repeatedly branch 1-3 times; 6) sterile branches sometimes present; 7) typically two branches can be seen to arise from a common bulbous base; 8) dark giant sporangiola though rare, may be present in old cultures.

Cunninghamella echinulata var. *antarctica* shares many common characters with *C. echinulata* var. *echinulata, C. echinulata* var. *nodosa* and *C. echinulata* var. *verticillata*. All the four have: 1) the same colour of colonies though the colonies are granulate in *C. echinulata* var. *antarctica* and *C. echinulata* var. *verticillata* but, usually not granulate in *C.*

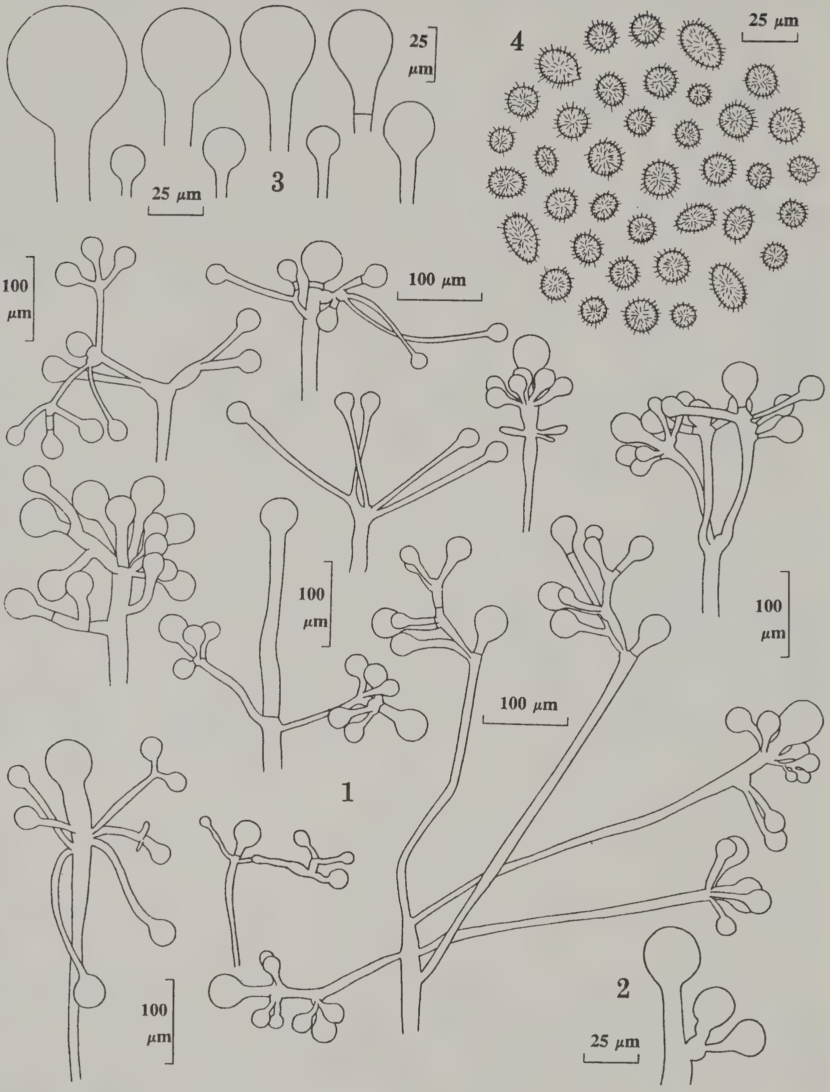

Fig. 6. *Cunninghamella echinulata* var. *antarctica*. 1. Terminal portions of sporophores showing characteristic branching patterns. Note that the sporophores broaden upwards and either terminate with a vesicle or do not terminate and directly divide into two to many branches at the apex of the main stem; the branches are typically long and short in the same sporophore and may repeatedly branch 1-3 times; two branches may arise from a common bulbous base. 2. Two branches from a common bulbous base in higher magnification. 3. Vesicles. 4. Sporangiola. [1-4. CBS 545.75, type].

echinulata var. *echinulata* and *C. echinulata* var. *nodosa*; 2) two kinds of fruiting structures, though the shorter type is frequently encountered in *C. echinulata* var. *echinulata* and *C. echinulata* var. *nodosa* but less often seen in the other two varieties; 3) dark giant sporangiola in old cultures though they are much less in number in *C. echinulata* var. *antarctica* and appear much later in *C. echinulata* var. *nodosa*; and 4) maximum growth temperatures of these four varieties are within the same range of (37-)39-42°C. Recent studies on the systematic relationship of *Cunninghamella* taxa inferred from sequence comparisons of ITS of rDNA have revealed that the four ex-type cultures CBS 156.28, CBS 545.75, Cu-34 and CBS 595.68 of *C. echinulata* var. *echinulata, C. echinulata* var. *antarctica, C. echinulata* var. *nodosa* and *C. echinulata* var. *verticillata* respectively are closely related and should be treated as different varieties belonging to the same species (Liu *et al.*, 2001). The main differences between *C. echinulata* var. *echinulata* and *C. echinulata* var. *verticillata* are discussed under *C. echinulata* var. *verticillata*, as for *C. echinulata* var. *antarctica*, the most striking difference distinguishing itself from the other three lies in the branching type of the sporophores which is reminiscent of *C. bertholletaie* but unlike those of *C. echinulata* var. *echinulata, C. echinulata* var. *nodosa* and *C. echinulata* var. *verticillata*. The presence of a common bulbous base giving rise to a pair of branches is also very characteristic for this variety.

Cunninghamella echinulata var. *antarctica* has not been reported since it was described in 1977, and its ex-type culture CBS 545.75 is the only strain available for study. Lunn & Shipton (1983) reported zygospore formation between IMI 213917 (= CBS 545.75) and the ex-neotype culture of *C. echinulata*, and synonymized *C. antarctica* with *C. echinulata* var. *echinulata*. In the present study, CBS 545.75 did not react with all the (+) and (−) strains with strong mating ability of either *C. echinulata* var. *echinulata*, including CBS 156.28, the ex-neotype culture of this taxon, or both *C. echinulata* var. *nodosa* and *C. echinulata* var. *verticillata*. In interspecific matings, CBS 545.75 likewise did not show any response at all with any of the (+) and (−) strains with strong mating ability of all the other taxa of *Cunninghamella* at hand. Hence, the mating type of CBS 545.75 is at present indeterminate.

Cunninghamella echinulata var. ***nodosa*** R. Y. Zheng var. nov. (Fig. 7; PL. VIII: 1-11)

Coloniae in SMA floccosae, 9 cm diam. in 4-5 diebus ad temp. 28°C crescentes, circa 1 cm altae, primo albae, deinde cremeae ad luteolas, a quintis die prope 'Pinkish Buff' (Ridgway XXIX), inverse dilute flavae. Hyphae ramosae, nonseptatae, tarde septatae, 4-14 μm diam. *Stolons* praesentes. *Rhizoidea* communia, simplecia vel repetite ramosa. *Sporophora* erecta, recta vel recurvata, e stolonibus, rhizoideis oppositis vel non-oppositis, vel e hyphis aeriis enata et stolonoidea, hyalina, bigeneria: typicus typus longior et typus brevior; axibus omnino cum vesica terminali, in typo longiore parce superne amplificantibus vel subaequis ad aequos in latitudinem per omnes partes, 6-15(-18.5) μm diam., ramosis, typice cum compluribus intumescentiis et undatis, in typo breviore aequis in latitudinem, nonramosis et nonundatis, 20.5-46(-74) μm longis; ramis primis typorum longiorum solitaris vel binis, fere simplicibus, interdum 1(-2) reramosis, plerumque brevis, (4.5-)18.5-92(-148) μm longis, superne amplificantibus vel aequis in latitudinem, (2.5-)5.5-11.5(-14) μm diam., fere cum vesica terminali, ramis sterilibus aliquando praesentibus. *Septa* in sporophoro plerumque absentia, interdum formata in basi ramorum. *Vesicae* in typo longiore globosae, ovoideae, vel subclavatae, in axibus 13-32.5(-39) μm diam., in ramis 9-25.5 μm diam., fere aliquantum angulares, raro laeves, hyalinae vel majores brunneolae, perfere proliferae et fortasse repetite proliferae pluries, fertiles et supra superficies suas totas pedicellos numerosos effomantes; vesiculae in typo breviore subovoideae ad subclavatas, 7-12.5 μm diam., e superdimidiata parte vesiculae solum pedicellos enata. *Pedicelli* tenues, 4.5-7.5(-11) μm longi. *Sporangiola* in pedicellis e vesicae enata, globosa et 5.5-14.5(-17) μm diam. vel late ellipsoidea et 9-16 × 8.5-14.5 μm, hyalina ad subbrunneola, spinis modice longis et confertis, sporangiolis atris et giganteis tantum e 16 diebus efformatis. *Sporangiosporae* disjungentes e sporangiolis, sine spinis sed tuberculatae, similes in forma et magnitudine sporangiolis quae eas gerentia. *Chlamydosporae* absentes. *Zygosporae* ignotae.

HOLOTYPUS **HMAS 80705-1—7**: cultura exsiccata ex **Cu-34** (= AS 3.5628), isolata e flore marcido de Zhongguancun, Beijing a G. Q. Chen, 15 Augusto 1986, in Herbarium Mycologicum Instituti Microbiologici Academiae Sinicae (HMAS) conservata.

Colonies on SMA floccose, reaching 9 cm diam. in 4 to 5 days at 28°C, about 1 cm high, at first white, then cream to yellowish, from the fifth day near 'Pinkish Buff' (Ridgway XXIX), reverse light yellow. *Hyphae* branching, nonseptate when young, septate in age, 4-14 μm diam. *Stolons* present. *Rhizoids* common, simple to repeatedly branched. *Sporophores* erect, straight or recumbent, arising from stolons, sometimes opposite rhizoids, or directly from aerial hyphae and stolon-like, colorless, of two intergrading kinds: the typical longer type and the shorter type; main axes terminating in a vesicle and with lateral branches, or without a terminal vesicle and branching directly into 2-several branches, slightly broadening upwards or subequal to equal in width throughout, 6-15(-18.5) μm diam., typically with one to several swellings and nodulous in the longer type; always terminating in a vesicle and remaining simple, equal in width throughout, not nodulous, 20-46(-74) μm long in the shorter type; primary branches of the sporophores of the longer type 0-2(-5), single or in pairs, mostly simple, sometimes re-branching 1(-2) times, usually short, (4.5-)18.5-92(-148) μm long, enlarging upwards or equal in width, (2.5-)5.5-11.5(-14) μm diam., usually with a terminal vesicle, sterile branches occasional. *Septa* in sporophores usually absent, sometimes with a septum at the place of branching. *Vesicles* of the longer type sporophores globose, ovoid, or subclavate, terminal vesicles 13-32.5(-39) μm diam., lateral vesicles 9-25.5 μm diam., often somewhat angular, rarely smooth, hyaline or brownish in the larger vesicles, proliferation of vesicles very common and may repeatedly proliferate several times, giving rise over their entire surfaces to numerous pedicels; vesicles of the shorter type sporophores subovoid to subclavate, 7-12.5 μm diam., forming pedicels only at the upper part. *Pedicels* slender, 4.5-7.5(-11) μm long. *Sporangiola* borne on pedicels on vesicles, globose and 5.5-14.5(-17) μm diam., or a few broadly ellipsoid and 9-16 × 8.5-14.5 μm, hyaline to pale brownish, with moderately long, thick spines, dark, giant sporangiola formed only after 16 days. *Sporangiospores* detachable but usually remaining in the sporangiola, hyaline, spineless but tuberculate, similar in shape and size to the sporangiola bearing them. *Chlamydospores* absent. *Zygospores* unknown. Probably *heterothallic.*

Maximum growth temperature: 41°C

DNA length of respectively ITS1, 5.8S, ITS2 and entire ITS region: 235, 153, 419, 807 bp

Strain studied: **Cu-34** (= AS 3.5628; mating type unknown, from faded flower, Zhongguancun, Beijing, China; ex-Type).

Dried cultures: **HMAS 80705-1—7** [Holotype, prepared from **Cu-34**, are being preserved in the Herbarium Mycologicum Instituti Microbiologici Academiae Sinicae (HMAS)].

Characterization of *C. echinulata* var. *nodosa*: 1) colonies are cream to yellowish, then 'Pinkish Buff' and not powdery in appearance; 2) two different kinds of fruiting structures, the longer and the shorter type sporophores present; 3) dark giant sporangiola formed only after 16 days; 4) main axes of the longer type sporophores are nodulous and with several swellings; 5) vesicles often repeatedly proliferate; 6) vesicles of both longer and shorter type sporophores are somewhat

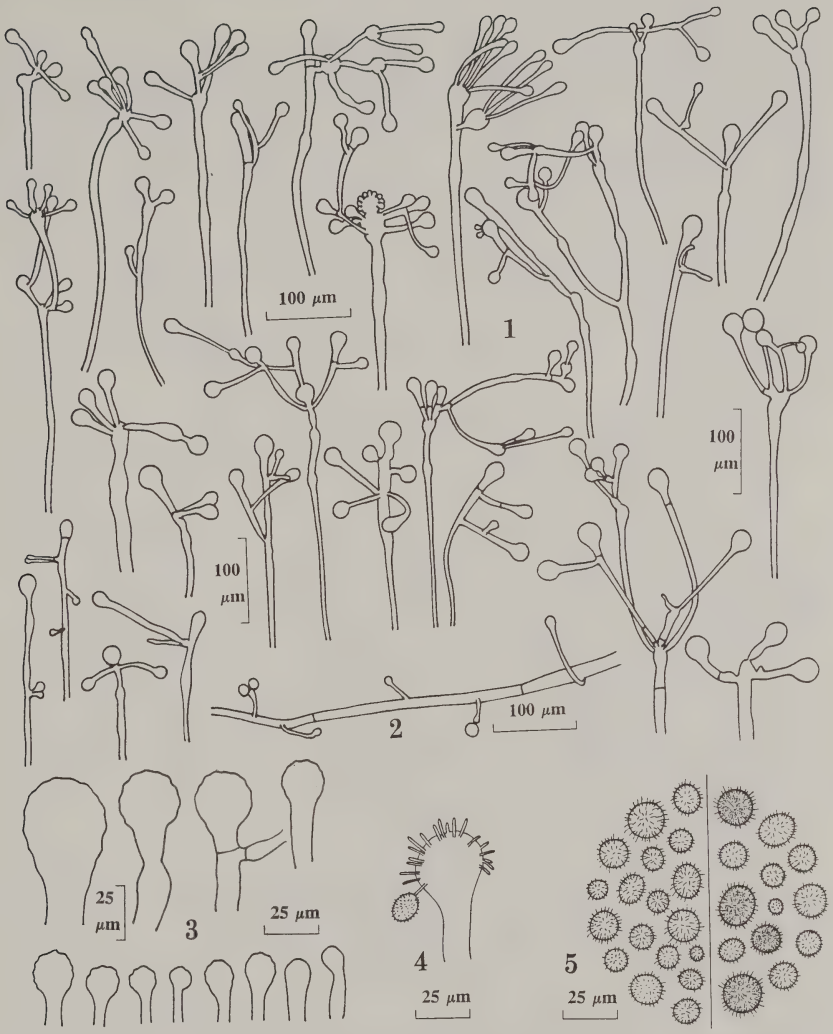

Fig. 7. *Cunninghamella echinulata* var. *nodosa*. 1. Terminal portions of the longer type sporophores showing characteristic branching patterns. Note that the main axes and some of the branches are typically nodulous, and many branches are arising directly from the vesicles. 2. Several shorter type sporophores on a mycelium. 3. Vesicles which are mostly somewhat angular. 4. A vesicle with long and slender pedicels. 5. Sporangiola from 5-day-old (left) and 16-day-old (right) cultures [1-5. Cu-34 (= AS 3.5628), type].

angular; 7) pedicels are slender and may reach 11 μm in length; 8) maximum growth temperature is 41°C.

Like the other varieties of *C. echinulata, C. echinulata* var. *nodosa* differs from all the other taxa of *Cunninghamella* by having two intergrading kinds of sporophores and dark giant sporangiola in old cultures. The new variety is further disinguished from all taxa including *C. echinulata* var. *echinulata*, var. *antarctica* and var. *verticillata* by possessing nodulous sporophores, proliferating vesicles, as well as the long and slender pedicels. *C. clavata* also has very long pedicels, but nothing else is similar to this new variety.

In crosses between *C. echinulata* var. *nodosa* and the + and – strains of all *Cunninghamella* taxa at hand, no response could be found.

Cunninghamella echinulata var. ***verticillata*** (F. S. Paine) R. Y. Zheng & G. Q. Chen, Mycosystema 8-9: 7. 1996. (Fig. 8; Pl. II: 6; Pl. IV: 6; Pl. V: 7-10)

= *Actinocephalum japonicum* Saito, Bot. Mag. Tokyo 19: 36. 1905.
    ≡ *Saitomyces japonicus* (Saito) Ricker, J. Mycol. 12: 61. 1906.
    ≡ *Cunninghamella japonica* (Saito) S. Ito, Mycological Flora of Japan. I. Phycomycetes. p. 304. 1936.
    ≡ *Cunninghamella japonica* (Saito) Pidopl. & Milko, Atlas Mucoral'nykh Gribov. p. 99. 1971. nom. inval.
= *Muratella elegans* Bainier & Sartory, Bull. Soc. Mycol. Fr. 29: 129. 1913.
    ≡ *Cunninghamella bainieri* Naumov, Clés des Mucorinées. p. 107. 1939.
= *Cunninghamella verticillata* F. S. Paine, Mycologia 19: 253. 1927.
    ≡ *Cunninghamella blakesleeana* var. *verticillata* (F. S. Paine) Baijal & B. S. Mehrotra, Sydowia 33: 98. 1980. (basionym)
= *Cunninghamella dalmatica* Pišpek, Acta Bot. Inst. Bot. Zagreb 4: 100. 1929.
= *Cunninghamella echinata* Pišpek, Acta Bot. Inst. Bot. Zagreb 4: 101. 1929.
= *Cunninghamella echinulata* var. *echinulata* sensu auct.: Milko & Beljakova, Mikrobiologiya 36: 687. 1967. p.p.; Samson, Proc. Kon. Ned. Akad. Wet., Ser. C, 72: 328. 1969. p.p.; Lunn & Shipton, Trans. Brit. Mycol. Soc. 81: 311. 1983. p.p.; non Blakeslee, Bot. Gaz. 40: 161. 1905.

Colonies on SMA at first floccose, soon becoming granulate, reaching 9 cm diam. in 5 to 6 days at 28°C, about 0.5-1 cm high, at first white, from the sixth day near 'Avellaneous' (Ridgway XL) to near 'Colonial Buff' (Ridgway XXX), reverse yellowish cream. *Hyphae* branching, nonseptate when young, septate in age, 3.5-14 μm diam. *Stolons* sometimes present. *Rhizoids* common, simple to repeatedly branched. *Sporophores* erect, straight or recumbent, arising from stolons, sometimes opposite rhizoids, or directly from aerial hyphae and stolon-like; main axes of sporophores all terminating in a vesicle, with lateral branches or very rarely without a terminal vesicle and branching directly into several branches, usually broadening upwards, 7.5-17.5(-25) μm diam., hyaline; branches (0-)4-15(-25), typically compact and arising from the main axes of sporophores in short distance, verticillate to pseudoverticillate, rarely singly or in pairs, mostly simple, very rarely re-branched, typically short and 10-75 μm long, occasionally reaching 250 μm. *Septa* in sporophores absent or present. *Vesicles* quite regular in shape, axial ones generally slightly depressed-globose, subglobose to globose, 22.5-50(-70) μm diam., lateral ones usually globose to subglobose, sometimes broadly ovoid, 8.5-27.5(-32.5) μm diam., all smooth and hyaline, giving rise over their entire surface to numerous pedicels, proliferation of vesicles occasional. *Pedicels* 2.5-4(-6.5) μm long. *Sporangiola* borne on pedicels on vesicles, generally of two kinds: either

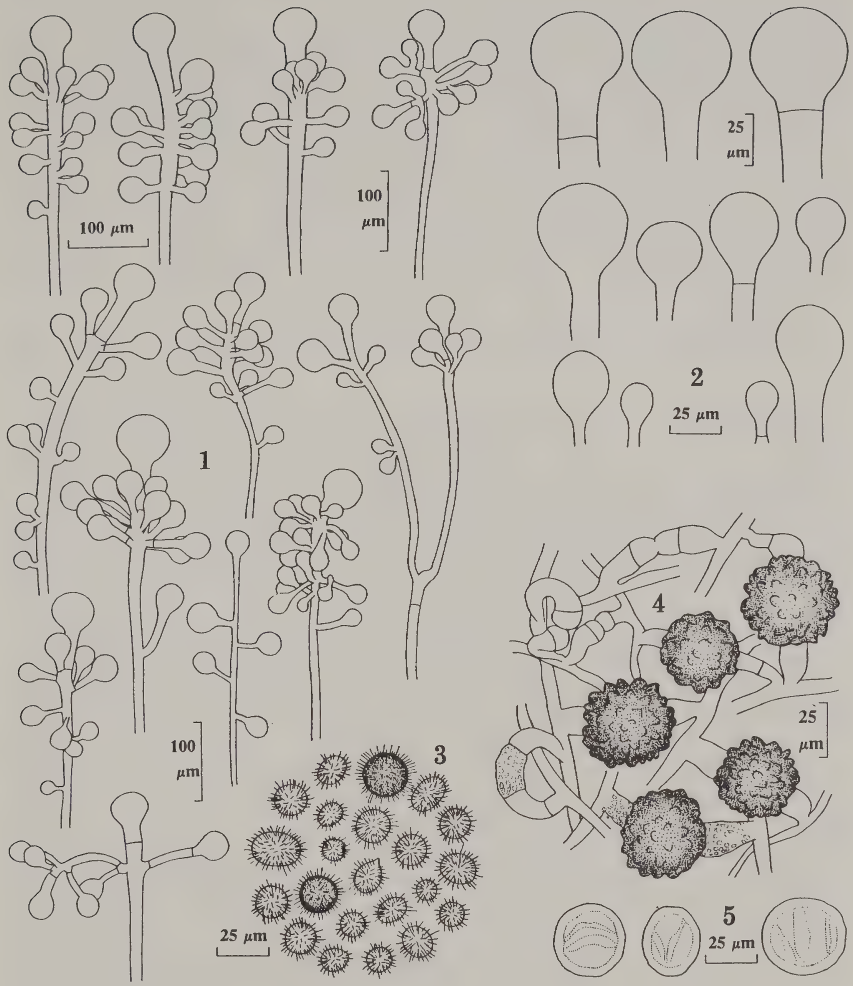

Fig. 8. *Cunninghamella echinulata* var. *verticillata*. 1. Terminal portions of sporophores showing characteristic branching patterns. Note that the main axes of the sporophores often enlarge upwards, terminating mostly with a vesicle, and the branches are usually short and similar in length on the same sporophore, typically compact and arising from the main stems in short distances, verticillate or pseudoverticillate, rarely single or in pairs, mostly not re-branching. 2. Vesicles. 3. Sporangiola with a few dark giant sporangiola interspersed. 4. Various stages of zygosporogenesis. Note that the two suspensors of a mature zygosporangium are equal in shape and not inflated, and typically remaining straight and not constricted at the base. 5. Detached zygospores. Note that the wall is thicker than those of the other taxa. [1-3. CBS 595.68, neotype; 4, 5. CBS 595.68(+) × Cu-22(–)].

hyaline, globose, broadly ellipsoid, ovoid and bluntly pointed at one end, 6-17.5(-20) × 5.5-13.5(-17.5) μm diam., or dark giant sporangiola, present in most strains but absent in some, exclusively globose, borne singly or intermixed with the hyaline ones on the same veiscle, 11.5-17.5(-25) μm diam., all evidently echinulate and with long thick spines, monosporous. *Sporangiospores* detachable, but usually remaining within the sporangiola, spineless, tuberculate, hyaline, similar in shape and size to the sporangiola bearing them. *Chlamydospores* absent. *Zygosporangia* globose to subglobose, 26.5-53.5 μm diam., dark brown when mature, with pointed wart-like projections. *Zygospores* mainly globose, rarely broad ellipsoid, 23-48 μm diam., wall usually very thick, more or less smooth to slightly crenulate, with indistinct ridges, hyaline. *Suspensors* equal, not inflated, 12.5-35.5 μm in length and 9-29.5 μm diam., slightly attenuated or typically remaining straight or broadening toward the base and reaching 20 μm wide; septa absent or formed at the basal part, not incrusted and hyaline or sometimes incrusted and brownish. *Heterothallic.*

Maximum growth temperature: (37-)39-42°C

DNA length of respectively ITS1, 5.8S, ITS2 and entire ITS region: 237, 155, 428, 820 bp

Strains studied: CBS 134.27 (= AS 3.5011; +, from soil, France; received as *C. echinulata*, originally identified by Y. Ling as *Muratella* sp.), **CBS 148.29** (= AS 3.4871; −, from soil, Yugoslavia; received as *C. echinulata*, ex-Type of *C. dalmatica* Pišpek), **CBS 149.29** (= AS 3.4872; +, from soil, Yugoslavia; received as *C. echinulata*, ex-Type of *C. echinata* Pišpek), **CBS 595.68** (= AS 3.4874; +, from peas, Canada; received as *C. echinulata*, originally as *C. bainieri* by V. M. Cutter; ex-Neotype, newly designated in this study), CBS 596.68 (= AS 3.4875; +, from *Hisbiscus* flower, USA; received as *C. echinulata*, originally as *C. bainieri* by V. M. Cutter), IMI 191785 (= AS 3.4829; +, from soil, Egypt; received as *C. echinulata*), IMI 199844 [−, from *Hisbiscus* flower, USA; received as *C. echinulata* and ? = CBS 596.68 (+), originally as *C. bainieri* by V. M. Cutter], IMI 201275 (= AS 3.4835; +, substratum unknown, South Africa, received as *C. echinulata*), Cu-20 (= AS 3.5621; −, from vegetable garden soil, Shennongjia, Hubei Prov., China), Cu-21 (from henhouse grasses, Fuzhou, Fujian Prov., China), Cu-22 (= AS 3.5622; −, from henhouse grasses, Wuyishan, Fujian Prov., China), Cu-23 (from grassland soil, Nanjing, Jiangsu Prov., China), Cu-25 (from humus, Nanjing, Jiangsu Prov., China), Cu-26 (from vegetable garden soil, Suzhou, Jiangsu Prov., China), Cu-27 (from paddy soil, Suzhou, Jiangsu Prov., China), Cu-28 (from soil under a tree, Suzhou, Jiangsu Prov., China), Cu-29 (= AS 3.5624; +, from orchard soil, Suzhou, Jiangsu Prov., China), Cu-30 (= AS 3.5625; −, from forest soil, Fuzhou, Fujian Prov., China), Cu-31 (from soil, Wuyishan, Fujian Prov., China), Cu-32 (= AS 3.5626; +, from vegetable garden soil, Nanchang, Jiangxi Prov., China), Cu-35 (= AS 3.5381; from soil, Chengdu, Sichuan Prov., China), Cu-37 (= AS 3.5629; −, from farmland soil, Nanning, Guangxi Prov., China); Cu-39 (= AS 3.5507; from sweet wrapping, Nanjing, Jiangsu Prov., China), Cu-42 (from air, Zhongguancun, Beijing, China), Cu-44 (from soil, Shanghai, China), Cu-46 (from vegetable garden soil, Beijing, China), Cu-47 (= AS 3.5634; −, from soil, Shanghai, China), Cu-48 (from soil under a tree in a park, Shanghai, China), Cu-51 (= AS 3.5635; +, from soil, Xiamen, Fujian Prov., China), Cu-55 (from soil, Xiamen, Fujian Prov., China), Cu-56 (from soil, Shanghai, China), Cu-57 (= AS 3.5504; +, from soil, Shanghai, China), Cu-64 (from soil, Xiamen, Fujian Prov., China), Cu-65 (from soil, Xiamen, Fujian Prov., China), Cu-66 (= AS 3.5642; +, from soil, Zhenjiang, Jiangsu Prov., China), Cu-68 (from soil, Fuzhou, Fujian Prov., China), Cu-69 (from soil, Shanghai, China), Cu-70 (from soil, Shanghai, China), Cu-73 (= AS 3.5645; +, from soil, Shanghai, China), Cu-75 (from soil, Shanghai, China), Cu-78 (= AS 3.5647; −, from faded flower, Nanjing, Jiangsu Prov., China), Cu-86 (= AS 3.1981; from soil, Hefei, Anhui Prov., China), Cu-87 (from wasteland soil, Guilin, Guangxi Prov., China), Cu-88 (= AS 3.5382; −, from soil, Zhenjiang, Jiangsu Prov., China), Cu-103 (= AS 3.5505; from orchard soil, Xiaowutaishan, Hebei Prov., China), Cu-145 (from faded flower, Lushunkou, Liaoning Prov., China), Cu-163 (= AS 3.5390; from vegetable garden soil, Dali, Yunnan Prov., China), Cu-167 (from bamboo forest soil, Baoshan, Yunnan Prov., China), Cu-168 (from soil, Baoshan, Yunnan Prov., China), Cu-206 (= AS 3.5398; from vegetable garden soil, Guiyang, Guizhou Prov., China), Cu-208 (from faded flower of hyacinth bean, Fangshan, Hebei Prov., China), Cu-209 (= AS 3.5506; from dried corn, Mentougou, Beijing, China).

Dried cultures: **HMAS 80489-1—9** [Neotype, designated here, prepared from **CBS 595.68**, are being preserved in the Herbarium Mycologicum Instituti Microbiologici Academiae Sinicae (HMAS)],

HMAS 80490-1—11 [prepared from CBS 595.68(+) × Cu-22(−)].

Characterization of *C. echinulata* var. *verticillata*: 1) colonies are 'Avellaneous' and powdery in appearance; 2) two kinds of fruiting structures may present, though the shorter type is only occasional; 3) main axes of sporophores are often slightly enlarged upwards and are mostly with a terminal vesicles; 4) branches are usually short and similar in length on the same sporophore, typically compact and arising from the main axes in short distance, verticillate to pseudoverticillate, rarely single or in pairs, mostly simple, very rarely re-branching; 5) dark giant sporangiola present abundantly in old cultures; 6) the two suspensors supporting the zygosporangium are equal in shape, usually not inflated, and typically remaining straight and not constricted at the base.

Many names have been used to represent *C. echinulata* var. *verticillata*, the most frequent of which is *C. bainieri*. Because *C. verticillata* is considered to be synonymous with *C. bainieri* it supersedes the latter by priority as the epithet '*verticillata*' has already been used at the rank of variety as *C. blakesleeana* var. *verticillata* (Baijal & Mehrotra, 1980) and must be adopted to make the combination (Zheng & Chen, 1996).

The characters for separating *C. echinulata* var. *echinulata* and *C. echinulata* var. *verticillata* are as follows: 1) two intergrading kinds of fruiting structures, the usually longer type and the shorter type are normally encountered in the former, but seldom seen and often absent in the latter; 2) the sporophores are monopodially or pseudoverticillately branched in the former, and more often verticillately or pseudoverticillately, but rarely monopodially branched in the latter; 3) the main axes of sporophores in the former are often equal in width throughout their lengths and approximately 5-15(-18) μm diam., while in the latter, they clearly broaden upwards with a diameter of 7.5-20(-25) μm; 4) the number of primary branches of a sporophore is approximately 0-4(-10) and (0-)4-15(-25) in the former and the latter respectively; 5) branches of the former are often long and short on the same sporophore and with a length of approximately 20-150(-250) μm, while those of the latter are often similar in length on the same sporophore and approximately 10-75(-250) μm long; 6) terminal vesicles on the main axes of sporophores are mainly globose to subglobose, but somewhat depressed-globose in the longer type of the former and the latter respectively, vesicles of the shorter type of sporophores are however, subclavate and similar in shape in both taxa; 7) the sizes of terminal vesicles on the main axes of sporophores are usually 13-30(-40) μm and 22-50(-70) μm diam. in the former and latter respectively (Zheng & Chen, 1996). Furthermore, the DNA lengths of ITS1, 5.8S, ITS2 and entire ITS region are found to be 228, 154, 419, 801, and 237, 155, 428, 820 bp in the former and the latter respectively (Liu *et al.*, 2001).

As mentioned above, *C. echinulata* var. *echinulata* and *C. echinulata* var. *verticillata* form zygospores easily in both intravarietal and intervarietal matings but neither of them mate with either *C. echinulata* var. *antarctica* or *C. echinulata* var. *nodosa*. Zygosporic characteristics of *C. echinulata* var. *echinulata* × *C. echinulata* var. *echinulata, C. echinulata* var. *verticillata* × *C. echinulata* var. *verticillata*, and *C. echinulata* var. *echinulata* × *C. echinulata* var. *verticillata* are very much alike except that the wall of the zygospores formed by the last two kinds of crossings may appear to be thicker than those formed by the first kind of crossings (see

Plate V, Figs. 6, 8 and 10 for comparison).

The isolate IMI 199844 which is an equivalent of CBS 596.68 (+) according to the CBS Catalogue and IMI Catalogue, was found to be (−) in its mating type. When mated with (+) and (−) strains of *C. echinulata* var. *verticillata*, it formed zygospores with CBS 134.27(+), Cu-32(+), Cu-66(+), Cu-73(+), and formed gametangia with Cu-29(+), and Cu-57(+); when mated with (+) and (−) strains of *C. echinulata* var. *echinulata*, it formed zygospores with Cu-16(+), Cu-24(+), Cu-41(+), Cu-91(+), and formed gametangia with CBS 156.28(+), and Cu-71(+).

No original material of *C. echinulata* var. *verticillata* is extant, **HMAS 80489-1—9**, dried culture of **CBS 595.68**, are here designated as the Neotype of *C. echinulata* var. *verticillata* and deposited in the Herbarium Mycologicum Instituti Microbiologici Academiae Sinicae (HMAS). Liquid nitrogen preserved cultures, lyophilised cultures, as well as cold storage cultures of CBS 595.68 are kept in the Culture Collection of the Institute of Microbiology, Academia Sinica (AS) as **AS 3.4874**.

Cunninghamella elegans Lendn., Bull. Herb. Boissier 7: 250. 1907. (Fig. 9; Pl. III: 3; Pl. IV: 7; Pl. VI: 1, 2)

≡ *Cunninghamella echinulata* var. *elegans* (Lendn.) Lunn & Shipton, Trans. Brit. Mycol. Soc. 81: 312. 1983. p.p.

= *Cunninghamella elegans* var. *chibaensis* Hoshino, I. Takano & Kuwab., Tech. Bull. Fac. Hort. Chiba Univ. 17: 37. 1969. nom. inval.

Colonies on SMA floccose, reaching 9 cm diam. in 5 or 6 days at 28°C, about 1 cm high or higher, at first white, becoming 'Pale Neutral Grey' (Ridgway LII) at the sixth day, reverse greyish-white. *Hyphae* branching, nonseptate when young, septate in age, 3-11.5 μm diam. *Stolons* sometimes present. *Rhizoids* frequent, finger-like or root-like, simple or repeatedly branched, long or short. *Sporophores* erect, straight or recumbent, arising from stolons, sometimes opposite rhizoids, or directly from aerial hyphae and stolon-like; main axes of the sporophores all terminated with a vesicle, simple or branching, usually equal in width throughout, (5-)7.5-13(-16) μm diam.; branches 1-6(-12), single, in pairs, or 1-2 whorls of 3-8, forming at some distance below the terminal vesicle, (15-)50-90(-200) μm long, typically simple, but sometimes re-branching and giving rise to secondary branches in some strains, all terminated with a vesicle. *Septa* in sporophores usually absent and rarely formed. *Vesicles* quite regular, globose, subglobose, to broad ovoid, very rarely irregular in shape, smooth, hyaline, axial ones (17.5-)23-30.5(-40) μm diam., lateral ones 7.5-20.5(-27.5) μm diam., giving rise over their entire surface to numerous pedicels, proliferation of vesicles sometimes occurring. *Pedicels* 2.5-3.5(-6) μm long. *Sporangiola* borne on pedicels on vesicles, ellipsoid, ovoid, or globose, with or without a pointed end, 7-16.5(-22.5) × 5-11.5 μm or 5-9 μm diam., rarely very long and irregularly shaped sporangiola reaching a length of 47 μm may occur in some strains, greyish to brownish, shortly but evidently echinulate, monosporous. *Sporangiospores* detachable, but usually remaining within the sporangiola, spineless, tuberculate, hyaline, similar in shape and size to the sporangiola bearing them. *Chlamydospores* absent. *Zygosporangia* subglobose to slightly depressed-globose, 27-59 μm diam., reddish-brown when mature, warted, with blunt projections, monosporous. *Zygospores* globose, subglobose to ellipsoid, 21.5-54 μm diam., wall medium in thickness, sub-smooth to slightly crenulate, with indistinct ridges, hyaline. *Suspensors* mostly unequal in shape and size, typically one asymmetrically inflated and one not inflated, rarely equal, with both suspensors inflated or not inflated, in either case, all suspensors attenuated and not exceeding 10 μm at the very base, septa generally absent, often incrusted, brownish-orange to pale brown, 14-41 μm in length and 9-34.5 μm diam. *Heterothallic*.

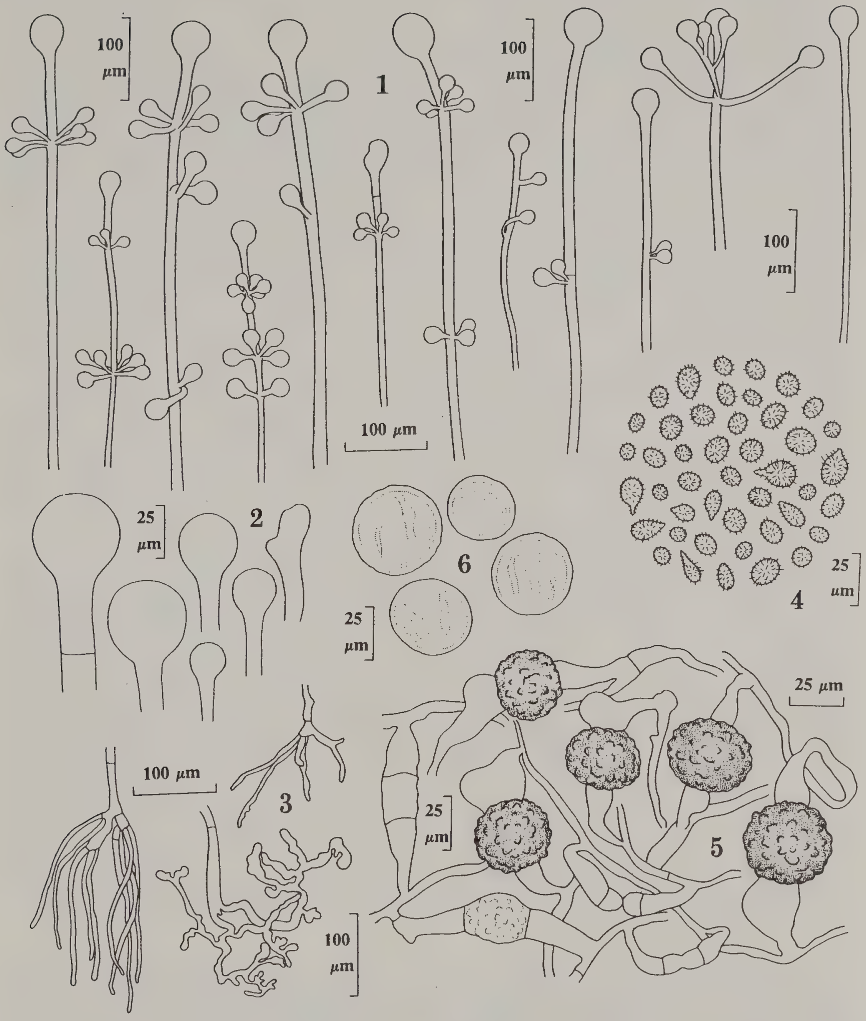

Fig. 9. *Cunninghamella elegans*. 1. Terminal portions of sporophores showing characteristic branching patterns. Note that the branches are rather short and of similar length on the same sporophore, are single, in pairs, or in whorls, often forming at some distance below the axial vesicle, mostly remaining simple and very seldom re-branched. 2. Vesicles. 3. Rhizoids. 4. Sporangiola. 5. Various stages of zygosporogenesis. Note that the two suspensors of a zygosporangium are typically unequal in shape, with one of them inflated unsymmetrically and ear-shaped. 6. Detached zygospores. [1-4. CBS 160.28, type; 5, 6. CBS 160.28(+) × Cu-10(−)].

Maximum growth temperature: (34-)35-36°C

DNA length of respectively ITS1, 5.8S, ITS2 and entire ITS region: 257, 154, 204, 615 bp

Strains studied: **CBS 160.28** (= AS 3.4876; +, from soil, USA; ex-Neotype), IMI 21199 (= AS 3.5063; −, substratum and origin unknown), IMI 154138 (= AS 3.4828; +, substratum unknown, Tanzania; originally as *C. phaeospora*), IMI 199767 (= AS 3.4832; +, substratum and origin unknown), IMI 200333 (= AS 3.4833; –, from soil, USA), MUCL 16087 (= AS 3.5769; from fish flour, Belgium; received as *C. blakesleeana*), MUCL 31518 (= AS 3.5770; substratum and origin unknown), NRRL 1378 (= AS 3.5080; −, from Brazil nuts, USA; received as *C. bertholletiae*), Cu-1 (from farmland soil, Shennongjia, Hubei Prov., China), Cu-2 (= AS 3.5618; −, from vegetable garden soil, Shennongjia, Hubei Prov., China), Cu-3 (from soil under an oak tree, Shennongjia, Hubei Prov., China), Cu-4 (= AS 3.5508; from animal dung, Shennongjia, Hubei Prov., China), Cu-5 (from forest soil, Shennongjia, Hubei Prov., China), Cu-6 (from soil under fallen leaves and twigs, Shennongjia, Hubei Prov., China), Cu-7 (= AS 3.5509; from grassland soil, Shennongjia, Hubei Prov., China), Cu-8 (from cave soil, Shennongjia, Hubei Prov., China), Cu-9 (from rotten grasses, Shennongjia, Hubei Prov., China), Cu-10 (= AS 3.5619; −, from rotten mushroom, Shennongjia, Hubei Prov., China), Cu-11 (from cornfield soil, Shennongjia, Hubei Prov., China), Cu-12 (= AS 3.5380; −, from soybeanfield soil, Shennongjia, Hubei Prov., China), Cu-13 (from broadleaf forest soil, Shennongjia, Hubei Prov., China), Cu-14 (from forest soil, Shennongjia, Hubei Prov., China), Cu-17 (= AS 3.5510; from vegetable garden soil, Shennongjia, Hubei Prov., China), Cu-18 (= AS 3.5511; −, from mouldy material, Shennongjia, Hubei Prov., China), Cu-36 (−, from soil, Chongqing, Sichuan Prov., China), Cu-40 (= AS 3.5631; from red soil, Kunming, Yunnan Prov., China), Cu-43 (from soil, Hangzhou, Zhejiang Prov., China), Cu-58 (= AS 3.5512; from soil, Shanghai, China), Cu-59 (from ant nest, Xiangshan, Beijing, China), Cu-60 (= AS 3.5638; −, from moth-eaten wood, Shennongjia, Hubei Prov., China), Cu-61 (= AS 3.5639; −, from soil, Zhenjiang, Jiangsu Prov., China), Cu-72 (= AS 3.5644; from soil, Shanghai, China), Cu-76 (from soil under a tree, Chengdu, Sichuan Prov., China), Cu-77 (= AS 3.5646; −, from soil under fallen leaves and twigs, Leshan, Sichuan Prov., China), Cu-85 (= AS 3.2028; from wasteland soil, Pingxiang, Guangxi Prov., China), Cu-95 (= AS 3.5650; +, from mouldy pine needles, Xiaowutaishan, Hebei Prov., China), Cu-104 (= AS 3.5654; +, from insect excrement on tree, Xiaowutaishan, Hebei Prov., China), Cu-112 (= AS 3.5684; from forest soil, Fanqingshan, Guizhou Prov., China), Cu-114 (from forest soil, Fanqingshan, Guizhou Prov., China), Cu-119 (from forest soil, Fanqingshan, Guizhou Prov., China), Cu-120 (from forest soil, Fanqingshan, Guizhou Prov., China), Cu-138 (= AS 3.5386; from soil by the roadside, Kowloon, Hong Kong, China), Cu-141 (from ant nest, Shennongjia, Hubei Prov., China), Cu-146 (from forest soil, Fanqingshan, Guizhou Prov., China), Cu-147 (from soil, Xishuangbanna, Yunnan Prov., China), Cu-148 (= AS 3.5387; from soil at a hill top, Hong Kong, China), Cu-149 (from soil, Gulangyu, Fujian Prov., China), Cu-150 (from soil, Xishuangbanna, Yunnan Prov., China), Cu-151 (= AS 3.5388; from rotten polypore, Tianmushan, Zhejiang Prov., China), Cu-152 (from soil, Shanghai, China), Cu-189 (from dried medicinal herbs, Shennongjia, Hubei Prov., China), Cu-201 (from ant nest, Menhai, Yunnan Prov., China), Cu-203 (= AS 3.5397; from grassland soil, Jinghong, Yunnan Prov., China), Cu-207 (= AS 3.5397; from vegetable garden soil, Dabashan, Sichuan Prov., China).

Dried cultures: **HMAS 80491-1—8** (Isotype, prepared from **CBS 160.28**), HMAS 80492-1—8 [prepared from CBS 160.28(+) × Cu-10(−)].

Characterization of *C. elegans*: 1) colonies are 'Pale Mouse Grey' (Ridgway LI), 'Pale Quaker Drab' (Ridgway LI), or 'Pale Neutral Grey' (Ridgway LII); 2) branches are typically rather short and of similar length on the same sporophore, single, in pairs, or 1-2 whorls of 3-8, usually forming at some distance below the axial vesicle, mostly remaining simple but in rare occasion may repeatedly branch; 3) dimension of sporangiola is quite small as compared with the other taxa, but irregularly shaped sporangiola reaching a length of 47 μm may also be encountered in a few strains; 4) the two suspensors are typically unequal in shape with one of them inflated asymmetrically and ear-shaped.

Cunninghamella elegans has been recognized by nearly all authors working on this genus. The only exception is Lunn & Shipton (1983) who reduced it to a variety under *C. echinulata* as *C. echinulata* var. *elegans*. In their classification, they only accepted three species comprising four taxa. *Cunninghamella homothallica* and *C. vesiculosa* were said to be readily separable based on the homothallic nature of the former and the distinctive vesicle shape and branching of the latter. The remaining taxa were said to be unseparable at the rank of species in terms of growth rate, growth at 37°C, colony and sporangiolum colour, colony height or texture, presence or absence of rhizoids, sporangiophore and hyphal diameter, vesicle dimensions or sporangiophore branching. Though Lunn & Shipton have already noted that *C. echinulata* and *C. elegans* can be separated on the basis of differences in zygosporangium (as 'zygospore') and suspensor morphology, they still considered this character 'not wholly useful' and preferred to accomodate all the taxa, excepting *C. homothallica* and *C. vesiculosa* but including *C. elegans,* in a single species, *C. echinulata*, and dividing them into two varieties. The taxa possessing sporangiola with long pointed spines like *C. antarctica, C. bainieri, C. brunnea, C. dalmatica, C. echinata, C. intermedia, C. ramosa* etc., were grouped in the type variety *C. echinulata* var. *echinulata*, and those with shorter, blunter spines like *C. bertholletiae, C. blakesleeana, C. elegans, C. phaeospora, C. polymorpha, C. verticillata* were grouped in *C. echinulata* var. *elegans*. Weitzman (1984) argued against the proposal of relegating *C. elegans* to varietal status as *C. echinulata* var. *elegans*, and claimed that *C. elegans, C. bertholletiae* and *C. echinulata* should be maintained as separate species; this view is followed here. Most of the characters, especially the morphology of the zygosporangia and suspensors, listed by Lunn & Shipton as unable to, or not useful in separating taxa, are very helpful in distinguishing them; while the spines on the sporangiola, as proven by Benjamin (1979), are composed of calcium oxalate and do not form a part of the sporangiolum wall proper, hence do not warrant their use as an important criterion for classifying species. In this paper, echinulation of sporangiola is mentioned in the descriptions of all taxa, and compared among different taxa as one of the items of the sporangiola in the Synoptic Key, but is neither used as a criterion for separating taxa in the Dichotomous Key, nor used as an important character for denoting the taxa.

Taxa treated by various authors as synonymous with *C. elegans* are discussed under those names.

Cunninghamella homothallica Komin. & Tubaki, *in* Komin., Kobayasi & Tubaki, Nagaoa 1: 21. 1952. (Fig. 10; Pl. I: 9, 10; Pl. IV: 8; Pl. VI: 3, 4)

Colonies on SMA low, 2-3 mm high, at first white, becoming 'Vinaceous-Fawn' (Ridgway XL) in the central portion due to the formation of the numerous zygosporangia, reverse similar but paler. *Hyphae* branching, nonseptate when young, septate in age, 3-10 μm diam. *Stolons* occasionally present. *Rhizoids* simple or branching, not abundant, sometimes opposite sporophores. *Sporophores* usually erect, arising from stolons or directly from aerial hyphae and stolon-like; main axes of sporophores terminated with a vesicle, mostly simple, sometimes with one side branch borne not far away from the axial vesicle, approximately equal in width throughout, (3.5-)5.5-8.5 μm diam., smooth, pale reddish-brown; branches simple, 3.5-5.5 μm diam., reaching a length of 350 μm, also terminated in a vesicle, sterile branches frequently present. *Septa* in sporophore 0-2(-4), without definite position. *Vesicles* subglobose, ovoid, narrowly ovoid to subclavate, axial ones 9-27.5 μm diam. and lateral ones 4.5-17.5 μm diam., giving rise to pedicels on the entire surface, or more often the upperhalf only, of the vesicles.

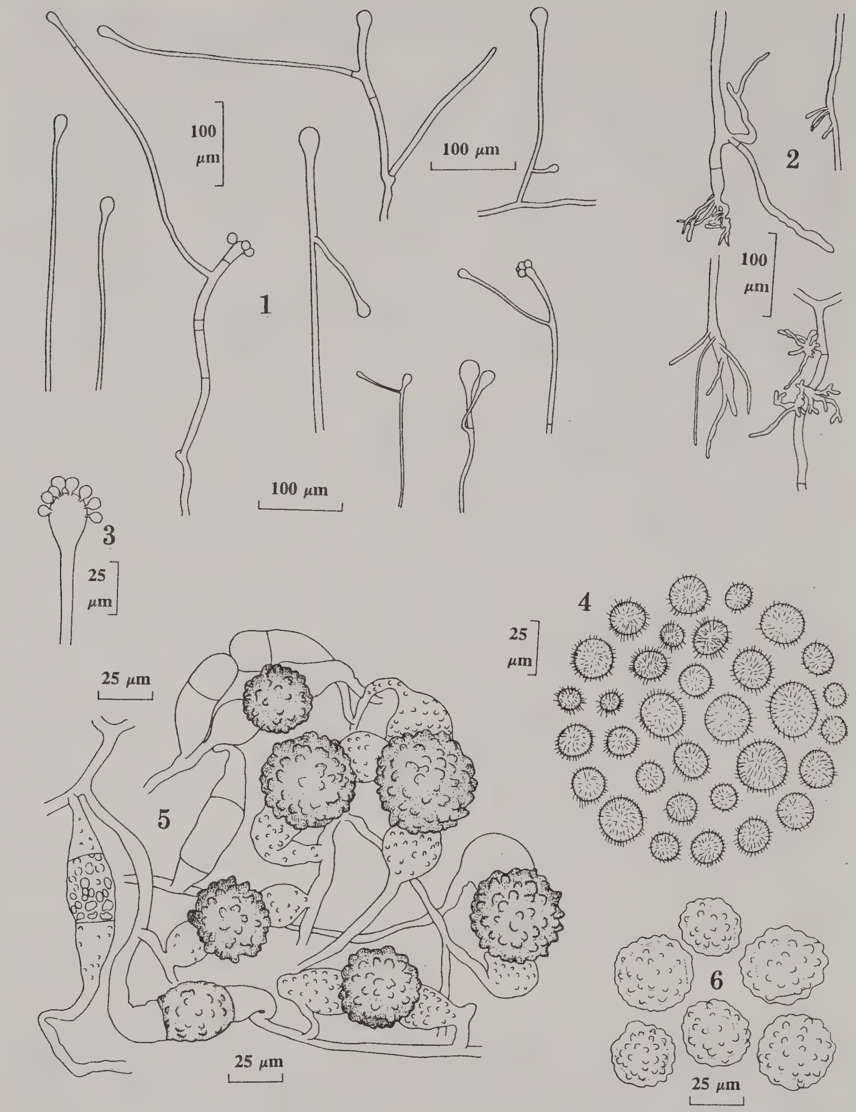

Fig. 10. *Cunninghamella homothallica*. 1. Terminal portions of sporophores showing characteristic branching patterns. Note that the sporophores are simple or only with one side branch; sterile branches sometimes present. Also note that many of the vesicles are subclavate in shape. 2. Rhizoids. 3. An enlarged vesicle showing the formation of sporangiola on its upperhalf surface. 4. Sporangiola. 5. Various stages of zygosporogenesis. Note that the two suspensors of a zygosporangium are equal in shape and size, inflated, heavily incrusted, and constricted at the base. 6. Detached zygospores which are tuberculate and different from those of the other taxa. [1-6. IFO 6736, type].

Pedicels short and indistinct. *Sporangiola* borne on pedicels on vesicles, mainly globose to subglobose, sometimes broadly ellipsoid, 10.5-20 μm diam. or 10.5-21.5 × 9.5-18 μm, hyaline, rarely pale brownish, with thick and moderately long spines, monosporous. *Sporangiospores* detachable, but usually remaining within the sporangiola, spineless, tuberculate, hyaline, similar in shape and size to the sporangiola bearing them. *Chlamydospores* absent. *Zygosporangia* mostly globose, very rarely somewhat irregularly globose, 32-50 μm diam., brown to dark brown, with roundish to obtusely pointed protuberances, monosporous. *Zygospores* globose to broadly ovoid, 25.5-45.5 μm diam. or 26.5-44 × 23-40 μm, evidently tuberculate, hyaline, thick-walled, often with a big oil drop in the center. *Suspensors* equal, broadening into an oval shape, 18-32(-36) μm long and 13.5-27.5 μm diam., often constricted at the base, pale reddish-brown, heavily incrusted, straight, rarely slightly curved. *Homothallic.*

Maximum growth temperature: 37°C

DNA length of respectively ITS1, 5.8S, ITS2, and entire ITS region: 241, 155, 215, 611 bp

Strain studied: **IFO 6736** (= AS 3.5060; ±, from soil, Japan; ex-Type).

Dried cultures: **HMAS 79280-1—8** (Isotype, prepared from **IFO 6736**). ,

Characterization of *C. homothallica*: 1) colonies are white but changing to vinaceous in the central portion due to the formation of numerous zygosporangia; 2) sporophores are mostly simple or rarely with a single side branch; 3) main axes of the sporophores are evidently short and slim comparing with the other taxa in the same genus; 4) sterile branches are frequently present; 4) mating behavior that is homothallic; 5) zygospores are tuberculate and different to those of other taxa.

The homothallic nature and the almost unbranched sporophores make *C. homothallica* very distinct from all the other taxa in the genus.

The ex-type culture of *C. homothallica*, IFO 6736, was used to mate with many strains of the other species to see if it could stimulate the formation of zygospores, but this failed in all cases.

Cunninghamella intermedia K. B. Deshp. & Mantri, Mycopath. Mycol. Appl. 28: 343. 1966. (Fig. 11; Pl. II: 7, 8; PL. IV: 9).

= *Cunninghamella brunnea* J. N. Rai, S. C. Agarwal & J. P. Tewari, J. Gen. Appl. Microbiol. 14: 443. 1968.

= *Cunninghamella phaeospora* sensu auct.: Samson, Proc. Kon. Ned. Akad. Wet., Ser. C, 72: 324. 1969. p.p.; non Boedijn, Sydowia 12: 348. 1958.

= *Cunninghamella echinulata* var. *echinulata* sensu auct.: Lunn & Shipton, Trans. Brit. Mycol. Soc. 81: 311. 1983. p.p.; non Blakeslee, Bot. Gaz. 40: 161. 1905.

Colonies on SMA floccose, reaching 9 cm diam. in 6 days at 28°C, about 1-1.5 cm high, at first white, soon becoming grey, at last 'Hair Brown' (Ridgway, XLVI), margin whitish, reverse greyish-white. *Hyphae* branching, nonseptate when young, septate in age, 5-18(-22) μm diam. *Stolons* sometimes present. *Rhizoids* usually simple and finger-like. *Sporophores* erect, straight or recumbent, arising from stolons, sometimes opposite rhizoids, or directly from aerial hyphae and stolon-like; main axes of the sporophores usually equal in width throughout, rarely slightly attenuating upwards, 7-13.5(-18.5) μm diam., all terminated with a vesicle, hyaline, sometimes pale brownish at the base, monopodially branched, with opposite or alternate branches, typically in groups, straight or curved, orientated in all directions; primary branches 1-10(-24), 23.5-235(-560) μm long, simple or re-branching into secondary branchlets, long or short in the same sporophore, often with an enlarged base, all terminated with a vesicle. *Septa* not infrequent, usually formed at a short distance above the place of branching or at the basal part of the branches. *Vesicles* mostly globose to subglobose, sometimes irregular in shape, typically and evidently angular with outer and inner walls not coincident with each other, axial vesicles 19-32(-46) μm diam., lateral vesicles 9-23(-32) μm diam., hyaline to brownish, proliferation of vesicles occasionally occurring, giving rise over their entire surfaces to numerous pedicels. *Pedicels* 2-3.5(-6) μm long. *Sporangiola* borne on pedicels on vesicles, exclusively globose, 8-23 μm diam., pale brownish to light brown, shortly but distinctly echinulate, monosporous. *Sporangiospores* detachable, but usually remaining within the sporangiola, spineless, tuberculate, hyaline, similar in shape and size to the sporangiola bearing them. *Chlamydospores* not seen. *Zygospores* unknown. Probably *heterothallic*.

Maximum growth temperature: 43°C

DNA length of respectively ITS1, 5.8S, ITS2, and entire ITS region: 285, 155, 343, 783 bp

Strains studied: **CBS 347.69** (= AS 3.5014; mating type unknown, from soil, India; ex-Type of *C. brunnea*; received as *C. phaeospora*), **IMI 200623** (= AS 3.4834; mating type unknown, from soil, India; ex-Type).

Dried cultures: **HMAS 80493-1—7** (Isotype, prepared from **IMI 200623**).

Characterization of *C. intermedia*: 1) colonies are 'Hair Brown' (Ridgway XLVI); 2) main axes of the sporophores are usually equal in width throughout, or are rarely slightly attenuated upwards, and with a terminal vesicle; 3) primary branches are many in number and typically monopodial but compact and in groups, sometimes enlarging at the base, often repeatedly branched, with branchlets orientated in all directions and long or short in the same sporophore; 4) vesicles are typically angular; 5) sporangiola are exclusively globose.

Deshpande & Mantri (1966) discribed this species on the basis of the sizes of primary and lateral vesicles, and sporangiola (as 'conidia') which were said to be intermediate among those of the other four species of *Cunninghamella* (names not mentioned) reported from Indian soils; and stated that, "another peculiarity of this fungus is the appearance of cellular structure inside the vesicle formation of tube-like structure and their bulging into conidia" with a drawing just as confusing. Important characters distinguishing *C. intermedia* from the other taxa were not reflected in the diagnosis.

In a paper published several years ago (Zheng & Chen, 1992), two serious mistakes were made in using the name *C. polymorpha* for the correct name of *C. bertholletiae*, and *C. brunnea* for the correct name of *C. intermedia*. At that time, we did not know that the former and the latter two names each were synonymous until we have studied some authentic cultures as well as some clinical isolates of *C. bertholletiae* and the ex-type culture of *C. intermedia*. A comparative study on IMI 200623 and CBS 347.69 (ex-type cultures of *C. intermedia* and *C. brunnea* respectively) revealed that the two are entirely identical not only in morphology, but also in maximum growth temperature (Table 2) and in sequence alignment in ITS2 region of rDNA (Liu *et al.*, 2001). Furthermore, both the ex-type cultures of the two names were isolated from soil in India. Since *C. intermedia* is an earlier name, *C. brunnea* is here reduced to synonymy with that name.

Cunninghamella intermedia and *C. brunnea* were respectively treated as a doubtful species and a synonym of *C. phaeospora* by Samson (1969) and Milko (1974), while they were both considered to be synonymous with *C. echinulata* var. *echinulata* by Lunn & Shipton (1983). The angular vesicles with outer and inner walls not coincident with each other, and the

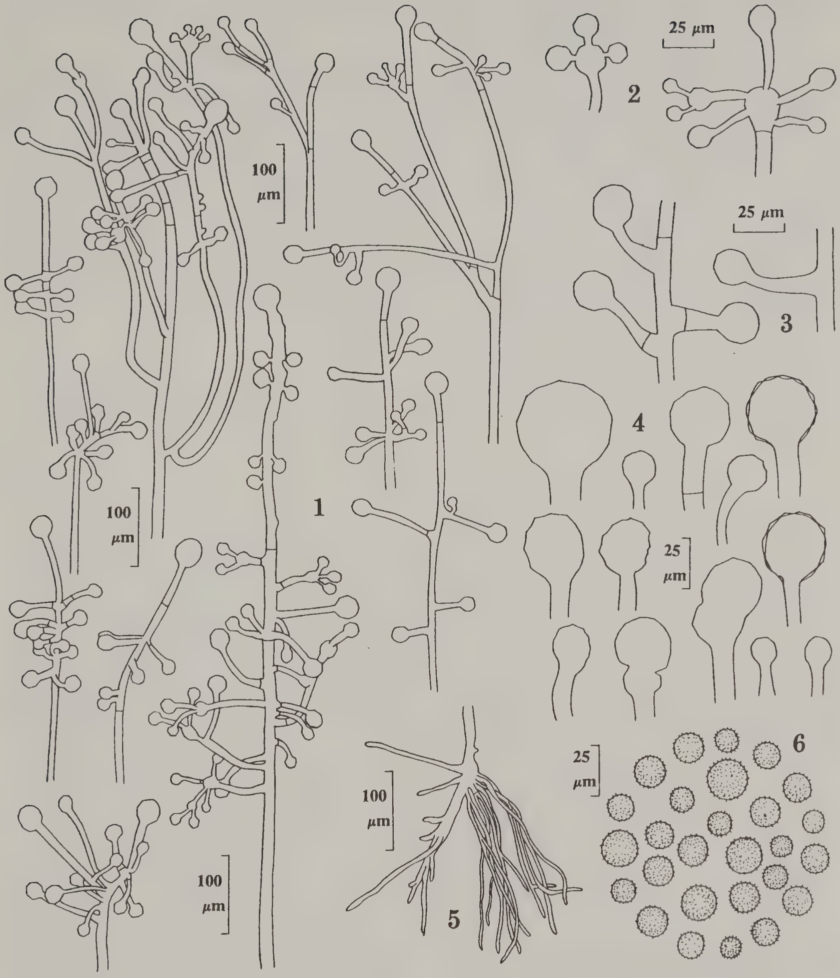

Fig. 11. *Cunninghamella intermedia*. 1. Terminal portions of sporophores showing characteristic branching patterns. Note that the main axes of the sporophores are usually equal in width throughout and terminate with a vesicle, the primary branches are many in number and typically monopodial but compact and in groups, sometimes enlarging towards the base, often repeatedly branched, with branchlets directed to all directions and long and short in the same sporophore. 2. Proliferation of vesicles. 3. Portions of the sporophores showing the enlarged base of the branches. 4. Vesicles of various shapes. Note that they are evidently angular, with outer and inner walls not coincident with each other. 5. Rhizoids. 6. Strictly globose sporangiola. [1-6. IMI 200623, type].

profusely branching sporophores with many branchlets growing out in groups in all directions are so characteristic that it is reasonable to maintain *C. intermedia* as a distinct species.

IMI 198490 (an equivalent of CBS 347.69), ex-type culture of *C. brunnea*, was reported to mate and form zygospores with two strains of *C. echinulata* var. *echinulata* (*C. echinulata* var. *verticillata*, according to this study), IMI 191785 and IMI 201275, while IMI 200623, ex-type culture of *C. intermedia*, was found to be incapable of forming zygospores in any crosses (Lunn & Shipton, 1983). Many strains, either (+) or (−), including many strong mating partners of all the *Cunninghamella* taxa presently available, including IMI 191785 and IMI 201275, were used to cross with CBS 347.69 and IMI 200623; no response could be detected. Neither did CBS 347.69 and IMI 200623 mate with each other. The mating type of both CBS 347.69 and IMI 200623 is indeterminable.

Cunninghamella multiverticillata (R. Y. Zheng & G. Q. Chen) R. Y. Zheng, comb. nov. (Figs. 12a, 12b; Pl. I: 6-8; Pl. IV: 11; Pl. VI: 7, 8)

≡ *C. phaeospora* Boedijn var. *multiverticillata* R. Y. Zheng & G. Q. Chen, Mycosystema 7: 1. 1994. (basionym)

Colonies on SMA floccose, reaching 9 cm diam. in 4 days at 28°C, about 1-1.5 cm high, white, becoming dirty white to pale greyish when old, reverse cream. *Hyphae* branching, nonseptate when young, septate in age, 4-13 μm diam., aerial hyphae very abundant. *Stolons* absent or present. *Rhizoids* very abundant and thick, arising from various parts of the hyphae, stolons, sporophores or vesicles, finger-like or root-like, delicate to stout, profusely branching, rarely simple, septate or nonseptate, straight, curved, or in a globose tangled mass. *Sporophores* erect, straight or recumbent, arising from stolon, rarely opposite rhizoids, or directly arising from aerial hyphae and stolon-like; main axes of sporophores all terminated with a vesicle, equal in width throughout, or rarely and slight broadening upwards, 7-13.5(-16.5) μm diam., hyaline, simple, or more often monopodially or verticillately branched, or in a mixture of both monopodially and verticillately branched; branches single, in pairs, or in 1-3 whorls of 3-8, usually 23-92 μm long including the vesicle, sometimes reaching a length of 500 μm, primary branches often simple and rarely re-branching to form secondary branchlets, all terminated in a vesicle. *Septa* in sporophores present or absent. *Vesicles* when axial clavate, ovoid, subglobose to irregularly shaped, 20.5-26.5 μm diam., lateral ones clavate or ovoid, sometimes somewhat pointed at the tip, 9-23 μm diam., all vesicles indistinctly angular, hyaline, rarely pale brownish, giving rise over their entire surface to numerous pedicels, proliferation of vesicles occurring occasionally. *Pedicels* 2-3.5(-6.5) μm long. *Sporangiola* borne on pedicels on vesicles, globose, subglobose, rarely ovoid and pointed at one end, 6-13 μm diam. or 8.5-13 × 7-11.5 μm, thickly echinulate, hyaline to brownish, monosporous. *Sporangiospores* detachable, but usually remaining within the sporangiola, spineless, tuberculate, hyaline, similar in shape and size to the sporangiola bearing them. *Chlamydospores* absent. *Zygospores* unknown. Probably *heterothallic*.

Maximum growth temperature: 41-42°C

DNA length of respectively ITS1, 5.8S, ITS2, and entire ITS region: 291, 155, 218, 664 bp

Strain studied: **Cu-137** (= AS 3.4683; +, previously as *C. phaeospora* var. *multiverticillata*, from broadleaf forest soil, Shennongjia, Hubei Prov., China; ex-Type).

Dried cultures: **HMAS 67734-1—8** (Holotype, prepared from **Cu-137**).

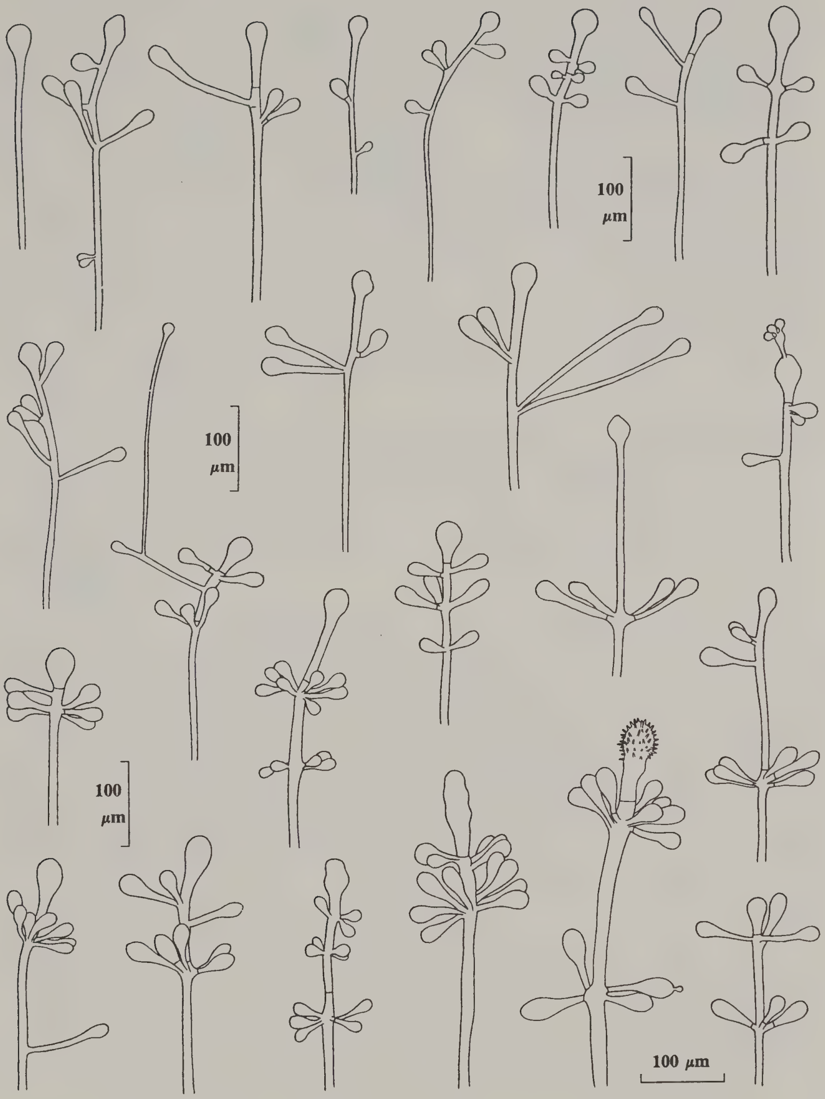

Fig. 12a. *Cunninghamella multiverticillata*. Terminal portions of sporophores showing characteristic branching patterns. Note that the sporophores are simple, monopodial, with 1-3 whorls of verticillate branches or partly monopodial and partly verticillate. [Cu-137 (= AS 3.4683), type].

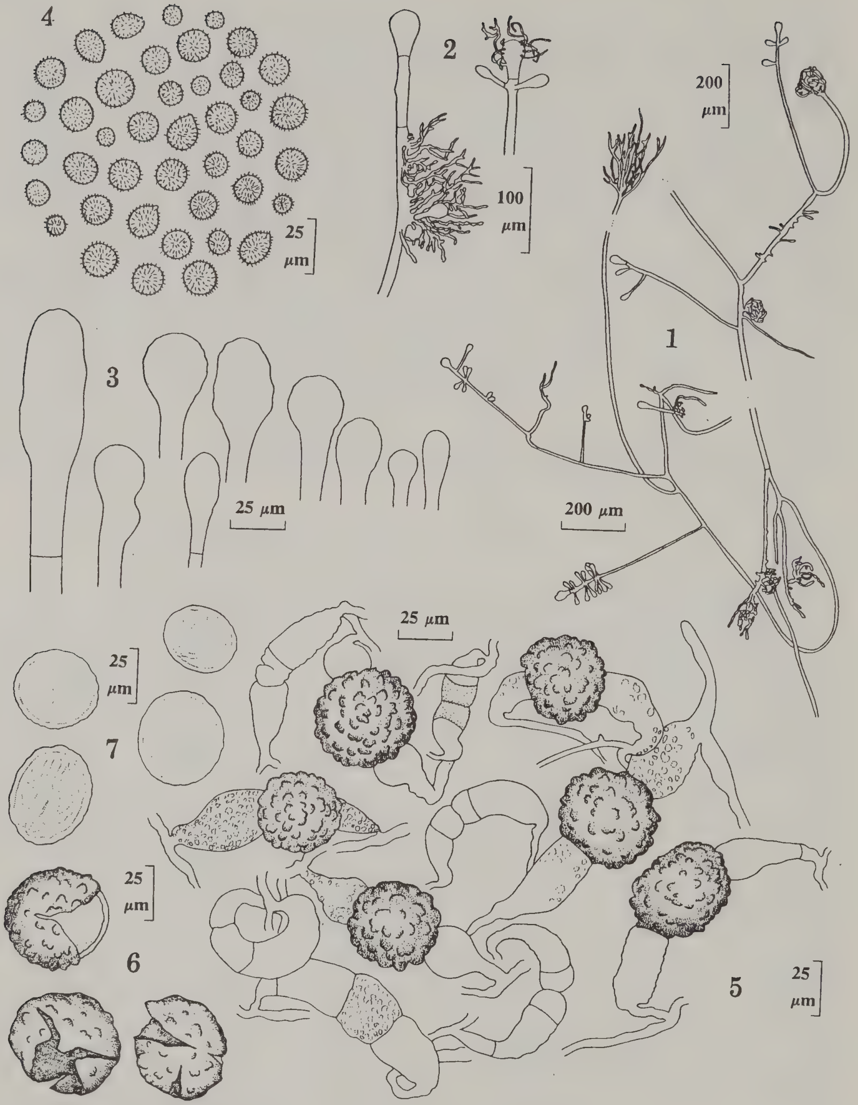

Fig. 12b. *Cunninghamella multiverticillata*. 1. General habit of sporophores. 2. Two sporophores, one with rhizoids growing out from the main axis, the other with rhizoids growing out from the terminal vesicle. 3. Vesicles of various shapes, many of them are irregular in shape and slightly angular. 4. Sporangiola. 5. Various stages of zygosporogenesis of *C. multiverticillata* × *C. phaeospora*. Note that the morphology of the zygosporangia and suspensors are similar to those formed in *C. phaeospora*. 6. Three cracked zygosporangia, two infertile and one fertile. 7. Four detached zygospores found from more than one hundred zygosporangia. [1-4. Cu-137 (= AS 3.4683), type; 5-7. Cu-137(+) × CBS 692.68(−)].

Characterization of *C. multiverticillata*: 1) colonies are white when young and dirty white when old, and with abundant aerial mycelia; 2) rhizoids are very abundant, arising from various parts of the hyphae, stolons, sporophores, or vesicles and often in a globose tangled mass; 3) the sporophores are partly monopodially, partly verticillately, or more often a combination of both monopodially and verticillately branched; 4) the axial vesicles are variously shaped and slightly angular, the lateral vesicles are frequently clavate; 5) sporangiola are hyaline to pale brownish.

Cunninghamella multiverticillata was originally described as a variety of *C. phaeospora* (Zheng & Chen, 1994). The reasons lay in the similarity of morphology and the formation of, though very scanty, zygospores between the two taxa. However, molecular systematic studies, including RFLPs in ITS region (Huang *et al.*, 1999), sequencing of ITS2 region (Su *et al.*, 1999), as well as of the entire ITS region (Liu *et al.*, 2001) have revealed that the two taxa are not conspecific and strongly supported that *C. multiverticillata* should be treated as a distinct species instead of a variety of *C. phaeospora*.

Except molecular evidences, morphologically *C. multiverticillata* differs from *C. phaeospora* in having: white to dirty white instead of deep grey colonies, more abundant rhizoids, true verticillate branches in 1-3 whorls of 3-8 branches, clavate vesicles on the lateral branches, hyaline to pale brownish instead of brownish to dark brown sporangiola; and physiologically, a much higher maximum growth temperature of 41-42°C versus (32-)34-35°C.

Cu-137 (= AS 3.4683), the only and ex-type culture of *C. multiverticillata*, is (+) in its mating type. It formed a great deal of zygosporangia when crossed with CBS 692.68 (−), ex-type culture of *C. phaeospora*, but formed only gametangia with Cu-136 (−), another strain of the same taxon. From more than one hundred mature zygosporangia harvested from Cu-137 (+) × CBS 692.68 (−), zygospores could only be found in four of them, the remaining zygosporangia being empty and infertile (Zheng & Chen, 1994). The morphology of the zygosporic state formed between the two species is similar to those formed between *C. phaeospora*(+) × *C. phaeospora*(−) (Pl. VI: 5-8).

Cunninghamella phaeospora Boedijn, Sydowia 12: 348. 1958. (Fig. 13; Pl. I: 3-5; Pl. IV: 10; Pl. VI: 5-8)

= *Cunninghamella batistae* H. P. Upadhyay & Ramos ex Samson, Proc. Kon. Ned. Akad. Wet., Ser. C, 72: 325. 1969. pro syn.

= *Cunninghamella elegans* sensu auct.: Milko & Beljakova, Mikrobiologiya 36: 686. 1967. p.p.; non Lendner, Bull. Herb. Boissier 7: 250. 1907.

≡ *Cunninghamella echinulata* var. *elegans* (Lendn.) Lunn & Shipton, Trans. Brit. Mycol. Soc. 81: 312. 1983. p.p.

Colonies on SMA floccose, reaching 9 cm diam. in 5 days at 28°C, about 1 cm high, at first white, soon becoming light grey, grey, to 'Deep Grey' (Ridway LI) or 'Quake Drab' (Ridgway LI), reverse greyish-white. *Hyphae* branching, nonseptate when young, septate in age, 2-10 μm diam., aerial hyphae very abundant. *Stolons* sometimes present. *Rhizoids* usually simple, but sometimes branching profusely, long or short, more often finger-like. *Sporophores* relatively scanty as compared with the other taxa, erect, straight or recumbent, rarely opposite rhizoids, or directly arising from aerial hyphae and stolon-like; main axes of the sporophores all terminated with a vesicle, equal or subequal in width throughout, sometimes slightly broadening upwards, (3.5-)5.5-9(-13) μm diam., hyaline, simple, or more often monopodially branched; branches single or in pairs, very rarely verticillate or pseudoverticillate, typically very sparse and relatively short in length, (9-)36-110(-200) μm long, primary branches usually simple and rarely re-branching to form secondary branchlets, all terminated in a vesicle. *Septa* in sporophores present or absent. *Vesicles* quite variable, ovoid, subglobose to irregularly shaped, smooth or indistinctly and slightly angular, terminal ones on the main axes 13.5-30(-36.5) μm diam., lateral ones from the branches 11.5-23(-32) μm diam., hyaline to pale brownish, giving rise over their entire surface to numerous pedicels, proliferation of vesicles occurring occasionally. *Pedicels* 2-3.5(-6) μm long. *Sporangiola* borne on pedicels on vesicles, mainly globose to subglobose, sometimes broadly ellipsoid, ovoid or lacrymoid, 5.5-12.5 μm diam. or 8.5-12.5 × 7-11 μm, thickly echinulate, brownish to dark brown, monosporous. *Sporangiospores* detachable, but usually remaining within the sporangiola, spineless, tuberculate, hyaline, similar in shape and size to the sporangiola bearing them. *Chlamydospores* absent. *Zygosporangia* slightly depressed-globose to globose, often irregularly globose, 29-62.5 μm diam., dark reddish-brown when mature, warted, with blunt projections, monosporous. *Zygospores* mostly ellipsoid, sometimes subglobose, 26-55 μm diam., outer wall thin, crenulate, with indistinct ridges, hyaline. *Suspensors* usually similar in shape but slightly unequal in size, 24-49(-73) μm long, symmetrically inflated and 12-34 μm diam., constricted to 4.5-12.5 μm at the base, usually without, but sometimes with, a basal septum, smooth or rarely and slightly incrusted, brownish. *Heterothallic*.

Maximum growth temperature: (32-)34-35°C

DNA length of respectively ITS1, 5.8S, ITS2, and entire ITS region: 282, 155, 204, 641 bp

Strains studied: CBS 158.28 (= AS 3.4877; +, from Brazil nuts, USA; received as *C. elegans*, originally as *C. bertholletiae* from Blakeslee), CBS 159.28 (= AS 3.4878; −, from Brazil nuts, USA; received as *C. elegans*, originally as *C. bertholletiae* from Blakeslee), **CBS 481.66** (= AS 3.4868; −, from soil, Brazil; received as *C. elegans*, ex-Type of *C. batistae*), **CBS 692.68** (= AS 3.5015; −, from soil, Indonesia; ex-Neotype), IMI 199346 (= AS 3.4831; −, from *Mymecodia* sp., Papua New Guinea; received as *C. elegans*, originally *C. phaeospora*), MUCL 10174 (= AS 3.5768; from soil, Zaire; received as *C. polymorpha*), NRRL 1376 (= AS 3.5079; −, from Brazil nuts, USA; received as *C. bertholletiae*), NRRL 1381 (= AS 3.5083; −, from Brazil nuts, USA; received as *C. bertholletiae*), Cu-113 (= AS 3.5655; from forest soil, Fanjingshan, Guizhou Prov., China), Cu-116 (= AS 3.5385; from forest soil, Fanjingshan, Guizhou Prov., China), Cu-136 (= AS 3.5564; −, from soil, Kowloon, Hong Kong), Cu-199 (= AS 3.5394; from soil under a tree, Xishuangbanna, Yunnan Prov., China).

Dried cultures: **HMAS 80494-1—8** (Isotype, prepared from **CBS 692.68**), HMAS 80495-1—8 [Cu-199(+) × CBS 159.68(−)].

Characterization of *C. phaeospora*: 1) colonies are 'Deep Grey' to "Quake Drab' (Ridgway LI), typically rich in aerial mycelia and poor in sporophores; 2) main axes of the sporophores are usually equal in width throughout; 3) branches are few in number and short in length, usually arising singly or in pairs, and very seldom form verticillate or pseudoverticillate branches or secondary branchlets; 4) axial vesicles are slightly angular and often irregular in shape; 5) suspensors are usually equal in shape and symmetrically inflated at the upper portion and constricted at the base; 6) spomgiola are brownish to dark brown, globose to subglobose in the first 3 or 4 days, but predominated by lacrymoid or ovoid ones afterwards.

Owing to the deep grey colour of the colonies, *C. phaeospora* has often been misidentified as either *C. elegans* or *C. bertholletiae*. In fact, *C. phaeospora* was already synonymized with *C. elegans* by Milko & Beljakova (1967) and Lunn & Shipton (1983, as *C. echinulata* var. *elegans*). Although *C. phaeospora* has never been published as a synonym

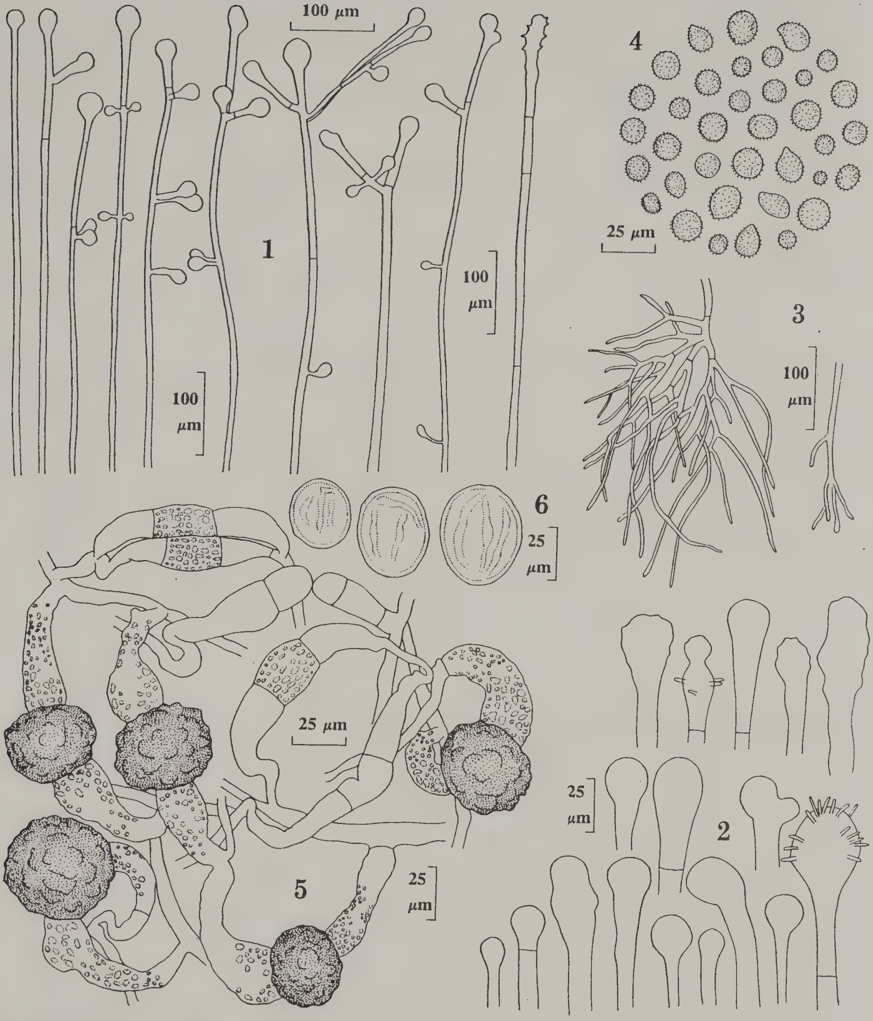

Fig. 13. *Cunninghamella phaeospora*. 1. Terminal portions of sporophores showing characteristic branching patterns. Note that the main axes of the sporophores are equal in width throughout, branches are few in number and short in length, usually arising singly or in pairs and seldom re-branched. 2. Vesicles of various shapes, many of them are irregular in shape and slightly angular. 3. Rhizoids. 4. Sporangiola. 5. Various stages of zygosporogenesis. Note that the two suspensors of a zygosporangium are equal in shape and symmetrically inflated at the upper portion and constricted at the base. 6. Detached zygospores. [1-4. CBS 692.68, neotype; 5, 6. Cu-199(+) × CBS 159.68(−)].

of *C. bertholletiae*, several isolates which seemed to have been used in the crossing experiments of Blakeslee *et al.* (1921) and which were received under this name, were found to be *C. phaeospora*. These taxa can readily be distinguished by their branching types as well as by their zygosporic characteristics (especially the suspensors) which are so different (see Figs. 1, 9, & 13 for comparison).

Two more names which have some relation to *C. phaeospora* are *C. brunnea* and *C. batistae* H. P. Upadhyay & Ramos. The former was treated as a synonym of *C. phaeospora* by Samson (1969) and Milko (1974) and the latter a synonym of *C. elegans* by Samson (1969) and a synonym of *C. japonica* (Saito) Pidopl. & Milko by Milko (1974). In this study, *C. brunnea* is considered to be conspecific with *C. intermedia*, and *C. batistae* with *C. phaeospora*.

The shape of the sporangiola of *C. phaeospora* has often been described as 'globose to subglobose' (Boedijn, 1958; Samson, 1969; Baijal & Mehrotra, 1980). The type culture, CBS 692.68, and the many more strains of this taxon studied here reveal that the shape of the sporangiola is globose to subglobose only in the first 3 or 4 days (Pl. IV: 10a), afterwards they are predominantly lacrymoid or ovoid (Pl. IV: 10b). The sporophores of CBS 692.68 was also described as verticillately branched in the diagnosis of *C. phaeospora* by Boedijn (1958), but was found to be principally monopodial and very rarely verticillate in this study. The other strains of *C. phaeospora* coincide with CBS 692.68 in their branching type.

Cunninghamella septata R. Y. Zheng sp. nov. (Figs. 14a, 14b; Pl. IX: 1-8).

Coloniae lente crescentes, 2-3 cm diam. in 4 diebus, 9 cm diam. in 14 diebus ad temp. 28°C in SMA, planae, circa 0.5-1 mm altae, granulatae, primo albae, deinde 'Avellaneous' (Ridgway XL) post 7 dies et 'Pinkish Cinnamon' (Ridgway XXIX) post 20 dies transformantes, inverse 'Pale Pinkish Buff' ad 'Pinkish Buff' (Ridgway XXIX). *Hyphae* ramosae, nonseptatae, tarde septatae, myceliis substratis 2.5-16 μm diam., myceliis aeriis absentibus. *Stolones* interdum praesentes. *Rhizoidea* digitaliformia vel rhizomorphoidea, simplicia vel ramosa. *Sporophora* erecta, recta vel recurvata, frequenter recta e myceliis substratis vel e stolonibus enata, rhizoideis non-oppositis; axibus sporophororum plerumque superne amplificantibus, 8-18.5 μm diam., semper cum vesica terminali; ramis primis 1-2(-4), raro simplicibus, saepe sympodice re-ramosibus ad modum flexuosum per 12 tempora; ramis (10-)32-140(-270) μm longis, superne amplificantibus, interdum subaequis ad aequos in latitudinem per omnes partes, (4.5-)9-14(-21) μm in latitudinem, cum vesica apicali praeditis in ramis fertilibus, ramis sterilibus aliquando praesentibus; axibus et ramis hyalinis ad subviridifuscos, saepe granulosis, vacuis post vetustos. *Septa* in axibus et ramis sporophororum plerumque praesentia, typice numerosa. *Vesicae* globosae, subglobosae, ovoideae ad subclavatas, aliquando leniter angulatae, granulosae, vacuae post vetustas, 18.5-37 μm diam. in axi et (7-)11-37 μm diam. in ramis, hyalinae vel subviridifuscae, interdum proliferae, supra superficies suas totas pedicellos numerosos efformantes. *Pedicelli* 2-4(-7) μm longi. *Sporangiola* in pedicellis e vesicae enata, plerumque globosa et 11-26(-29) μm diam., interdum late, raro anguste ellipsoidea et 14-21.5 × 10.5-20 μm hyalina, in massa dilute griseobrunnea, etiam granulosa quando juvenilia, spinis confertis et longis. *Sporangiosporae* disjungentes e sporangiolis, sine spinis, tuberculatae, similes in forma et magnitudine sporangiolis quae eas gerentia. *Chlamydosporae* absentes. *Zygosporae* ignotae.

HOLOTYPUS **HMAS 80704-1—8**: cultura exsiccata ex **Cu-230** (= AS 3.5766 et = MUCL 16098, isolata instar partis culturae commixtae de MUCL 16087 emmisa e Belgium a G. Q. Chen, 25 Julio 2000), in Herbarium Mycologicum Instituti Microbiologici Academiae Sinicae (HMAS) conservata.

Colonies on SMA very slow growing, reaching 2.3 cm diam. in 4 days and 9 cm in 14 days at 28°C on SMA, flat, about 0.5-1 mm high, granulous, at first white, becoming 'Avellaneous' (Ridgway XL) after 7 days and 'Pinkish Cinnamon' (Ridgway XXIX)

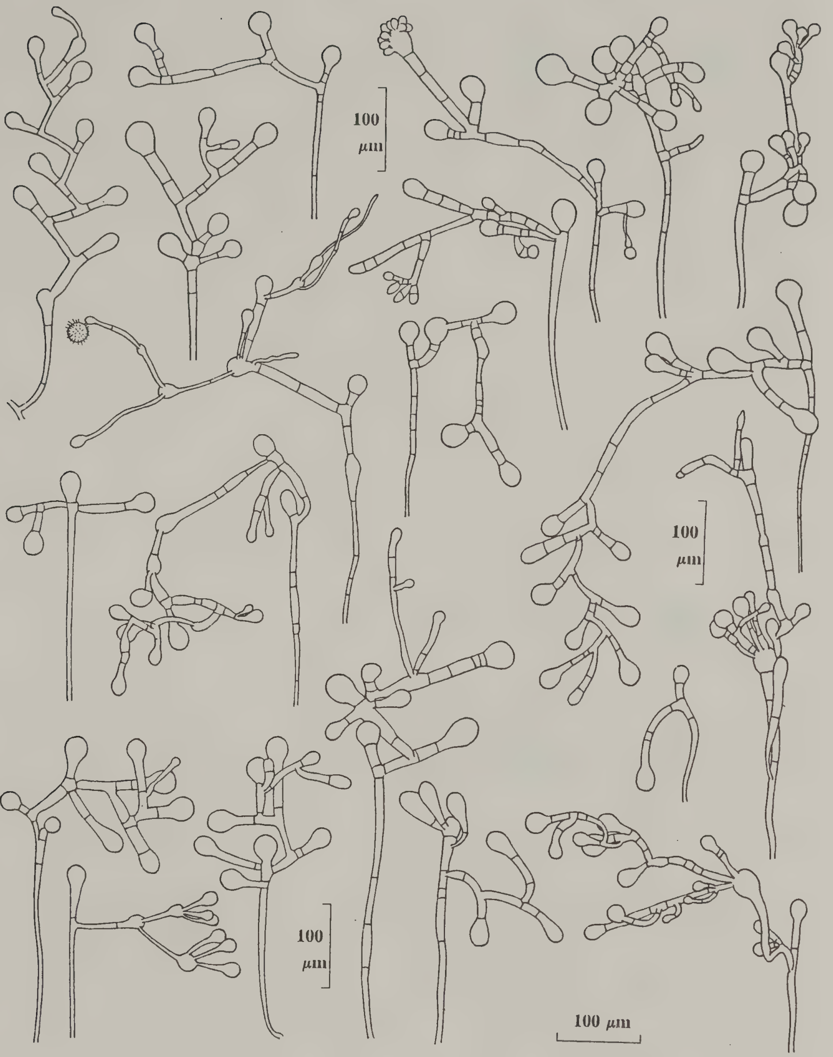

Fig. 14a. *Cunninghamella septata*. Terminal portions of sporophores showing characteristic branching patterns. Note that the main axes often enlarge upwards, either the main axes or the branches are typically multi-septate and the branches often branch in a zigzag manner up to 12 times. [Cu-230 (= AS 3.5766), type].

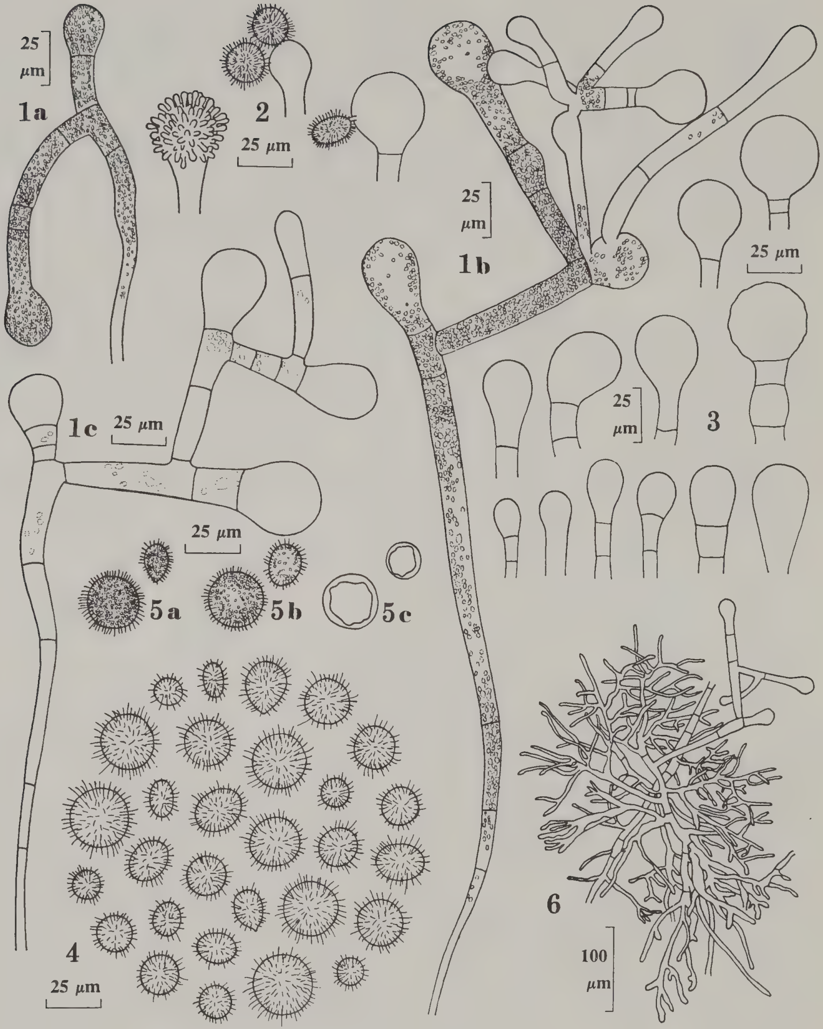
25 μm
1a
2
25 μm
25 μm
1b
25 μm
25 μm
3
1c
25 μm
25 μm
5a
5b
5c
4
25 μm
6
100 μm

Fig. 14b. *Cunninghamella septata*. 1. Granulation of sporophores from 1-, 2-, 3-week-old cultures (a, b, c respectively). 2.Vesicles with short, stout pedicels. 3. Variously shaped vesicles. 4. Sporangiola. 5. Granulation of sporangiola from 1-, 2-, 3-week-old cultures (a, b, c respectively). 6. A sporophore arising directly from the substrate mycelium. [1-6. Cu-230 (= AS 3.5766), type].

after 20 days, reverse 'Pale Pinkish Buff' to 'Pinkish Buff' (Ridgway XXIX). *Hyphae* branching, nonseptate when young, septate in age, substrate mycelia 2.5-16 μm diam., aerial mycelia absent. *Stolons* sometimes present. *Rhizoids* finger-like or root-like, simple or branching. *Sporophores* erect, straight or recumbent, often arising directly from substrate mycelia or from stolons, with non-opposite rhizoids; main axes of sporophores usually enlarging upwards, 8-18.5 μm diam., always with a terminal vesicle; primary branches 1-2(-4), rarely simple, often sympodially re-branching in a zigzag pattern up to 12 times; branches (10-)32-140(-270) μm long, enlarging upwards, sometimes subequal to equal in width throughout, (4.5-)9-14(-21) μm diam., terminating with a vesicle in the fertile branches, sterile branches occasional; main axes and branches hyaline to pale greenish brown, often with granulous contents, becoming vacuolate in age. *Septa* in main axes and branches of sporophores usually present and typically in large number. *Vesicles* globose, subglobose, ovoid to subclavate, occasionally slightly angular, granulous when young, vacuolate in age, axial vesicles 18.5-37 μm diam., lateral vesicles (7-)11-37 μm diam., proliferation sometimes present, giving rise to numerous pedicels over their entire surfaces. *Pedicels* 2-4(-7) μm long. *Sporangiola* borne on pedicels on vesicles, mostly globose, sometimes broadly and rarely narrowly ellipsoid, very rarely with a pointed end, 11-26(-29) μm diam. or 14-21.5 × 10.5-20 μm, hyaline, light greyish brown in mass, granulous when young, with long thick spines. *Sporangiospores* detachable, but usually remaining within the sporangiola, spineless, tuberculate, hyaline, similar in shape and size to the sporangiola bearing them. *Chlamydospores* absent. *Zygospores* unknown, probably *heterothallic*.

Maximum growth temperature: 35°C

DNA length of respectively ITS1, 5.8S, ITS2, and entire ITS region: 273, 154, 417, 844 bp

Strain studied: **Cu-230** (= AS 3.5766, MUCL 16098; mating type unknown, isolated as a component of the mixed culture MUCL 16087 sent from Belgium; ex-Type).

Dried cultures: **HMAS 80704-1—8**, [Holotype, prepared from **Cu-230**, are being preserved in the Herbarium Mycologicum Instituti Microbiologici Academiae Sinicae (HMAS)].

Characterization of *C. septata*: 1) colonies are low, flat and not exceeding 1 mm high; 2) aerial mycelia are absent with sporophores arising directly from substrate mycelia; 3) growth is extremely slow which takes at least 14 days to reach a diameter of 9 cm on SMA at 28°C; 4) septa are common and in large number on all parts of the sporophores; 5) branches typically branch in a zigzag manner up to 12 times; 6) all parts of the thallus including the main axes and branches of the sporophores, vesicles, sporangiola, are granulous when young but becoming vacuolate in age.

In the present studies of sequence analysis of rDNA ITS (Liu *et al.*, 2001), nearly all species clustered in different clades. *C. septata* is the only exception which clustered with the four varieties of *C. echinulata* in the same clade with 100% confidence. However, *C. septata* is so unique in morphology that none of the other taxa of this genus possesses even one of the characters listed above. It does not mate with any strain of any taxon. The maximum growth temperature of *C. septata* (35℃) is lower than that of the four varieties of *C. echinulata* [(37-)39-42℃]. Hence, it is considered to be a new species distinct from either *C. echinulata* or the other species.

Cunninghamella vesiculosa P. C. Misra, Can. J. Bot. 44: 441. 1966. (Fig. 15; Pl. III: 7, 8; Pl. IV: 12)

Colonies on SMA floccose, reaching a diameter of 6.5 cm in 6 days at 28°C, 3-5 mm high, pure white and remaining so afterwards, reverse creamy white. *Hyphae*

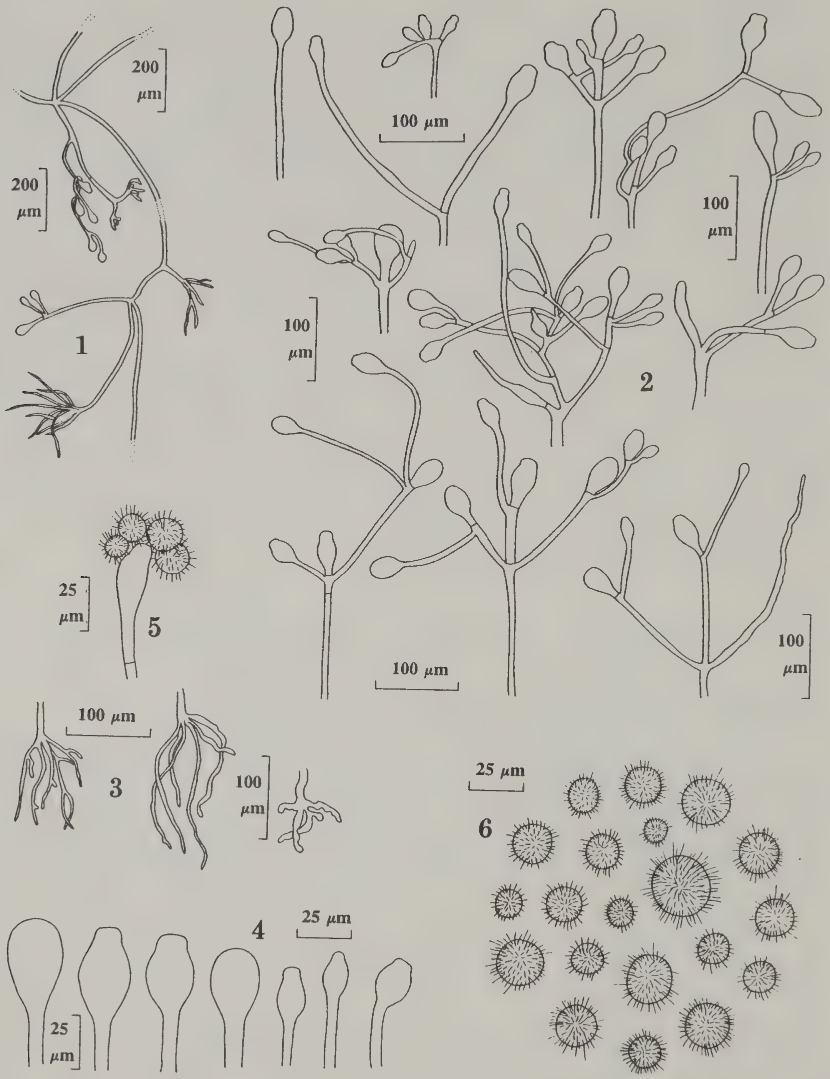
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Fig. 15. *Cunninghamella vesiculosa*. 1. General habit of sporophores. 2. Terminal portions of sporophores showing characteristic branching patterns. Note that the main axes of the sporophores are mostly equal in width throughout and repeatedly branched sympodially, with branches arising not far away from the vesicle of the former branch; sterile branches frequently present. 3. Rhizoids. 4. Vesicles that are typically inflated in the lower 4/5 part and narrowed in the upper 1/5 part. 5. A vesicle showing the formation of sporangiola on its upperhalf surface. 6. Sporangiola. [1-6. NRRL 3009, type].

branching, nonseptate when young, septate in age, 4.5-14 μm diam. *Stolons* present. *Rhizoids* simple or branching, hyaline. *Sporophores* erect, straight or recumbent, arising from stolons or directly from aerial hyphae and stolon-like; main axes of sporophores rarely simple, usually branching, terminating in a vesicle, rarely irregularly branched at the terminal portion and without an axial vesicle, equal in width throughout, sometimes slightly enlarging at the uppermost portion, rarely unequal in width throughout, (3-)5.5-9.5 μm diam., hyaline and smooth; primary branches 1-3, very frequently in pairs and opposite, never verticillate, remaining simple or re-branching sympodially 1-3 times, with branches arising not far away from the vesicle of the former branch, length of the branches 23.5-294 μm, substraight to curved, all terminating in a vesicle but sometimes infertile and mycelium-like. *Septa* in sporophores rarely absent, usually formed at the place of branching. *Vesicles* typically inflated in the lower 4/5 part and narrocwed in the upper 1/5 part, axial ones usually larger, 18-55 μm high, 10-23 μm and 11.5-27.5 μm diam. in the narrowed and inflated portions respectively, lateral ones smaller, 13.5-37 μm high, 7-14 μm wide and 9-20.5 μm diam. in the narrowed and inflated portions respectively, hyaline and smooth, giving rise to numerous pedicels over the surface of the upper narrowed portion. *Pedicels* 1.5-2 μm long. *Sporangiola* borne on pedicels on vesicles, subglobose to broadly ovoid, (8.5-)12.5-23(-28) μm diam., hyaline, with long, thick spines reaching a length of 6.5-9 μm, monosporous. *Sporangiospores* detachable, but usually remaining within the sporangiola, spineless, tuberculate, hyaline, similar in shape and size to the sporangiola bearing them. *Chlamydospores* absent. *Zygospores* unknown. Probably *heterothallic*.

Maximum growth temperature: 36-37°C

DNA length of respectively ITS1, 5.8S, ITS2, and entire ITS region: 302, 156, 311, 769 bp

Strain studied: **NRRL 3009** (= AS 3.4825; −, from forest soil, India; ex-Type).

Dried cultures: **HMAS 80496-1—8** (Isotype, prepared from **NRRL 3009**).

Characterization of *C. vesiculosa*: 1) colonies are persistently white; 2) branches of sporophores may repeatedly branch sympodially; 3) sterile branches present; 4) vesicles are typically inflated in the lower 4/5 part and narrowed in the upper 1/5 part.

Cunninghamella vesiculosa has only been reported once and the ex-type culture NRRL 3009 is the only representative of this species available for study. In interspecific matings, NRRL 3009 did not form zygospores with any of the isolates of all the other taxa, however, it formed gametangia with *C. clavata* Cu-185(+), hence it has a (−) mating type.

DOUBTFUL SPECIES

Cunninghamella albida (Sacc.) Matr., Ann. Mycol. 1: 56. 1903.
≡ *Oedocephalum albidum* Sacc., Michelia 2: 288. 1881.
= *Haplotrichium albidum* Sacc., Michelia 2: 288. 1881 & Fungi Italia. Fig. 805. 1881.

Cunninghamella albida was recognized by Lendner (1908), Zycha (1935), Alcorn & Yeager (1938), and Naumov (1939), treated as doubtful by Cutter (1946), Zycha *et al.* (1969), and Samson (1969), and excluded by Milko & Beljakova (1967) and Milko (1974). No type or other material was available for study, and since no conclusion could be drawn from the diagnosis or figure published, it is treated as a doubtful species.

Cunninghamella candida Yamam., Trans. Agric. Chem. Soc. Japan 5: 286. 1929.

The species has not been found since it was described and was not mentioned by any one working on the *Cunninghamella*. No type or other materials are available for study and the only description of this species currently available is the one written in Japanese and republished in "Mycological Flora of Japan I. Phycomycetes" by Ito (1936) ; the correct placement of this name could not be determined.

Cunninghamella echinulata var. ***indica*** Baijal & B. S. Mehrotra, Sydowia 33: 6. 1980.

This species has not been found since it was described and the type material has probably been lost. Based on the description of Baijal & Mehrotra (1980), *C. echinulata* var. *indica* is probably closely related to *C. clavata* (Zheng & Chen, 1998). Both taxa have many common characteristics, however, the unique branching type of sporophores found in *C. clavata* was neither mentioned nor illustrated in *C. echinulata* var. *indica*. This kind of branching is not common, it can be seen only after studying many preparations made from various parts of the colony of *C. clavata*. There is the possibility that if *C. echinulata* var. *indica* was re-found, it might turn out to be the same as *C. clavata*. However, *C. echinulata* var. *indica*, whether it is identical with *C. clavata* or not, is clearly more closely related to this species than to *C. echinulata*. Hence, until new material of *C. echinulata* var. *indica* is collected and restudied, it is here considered to be a doubtful taxon of the genus.

Cunninghamella indica Baijal & B. S. Mehrotra, Sydowia 33: 7. 1980.

Like *C. echinulata* var. *indica*, *C. indica* has not been found since it was described and the type material has probably been lost. According to the description provided by its authors (Baijal & Mehrotra, 1980), it seems to be an acceptable species different from the currently accepted taxa; it is retained as provisional until new material is collected and studied.

Cunninghamella ramosa Pišpek, Acta Bot. Inst. Bot., Zagreb 4: 102. 1929.

= *C. dalmatica* sensu auct.: Zycha, Mucorineae. *In*: Rabenhorst, Kryptogamenflora der Mark Brandenburg VIa. p. 169. 1935; Zycha, Linnemann & Siepmann, Mucorales. p. 148. 1969.; non Pišpek, Acta Bot. Inst. Bot., Zagreb 4: 100. 1929.

= *C. polymorpha* sensu auct.: Zycha, Mucorineae. *In*: Rabenhorst, Kryptogamenflora der Mark Brandenburg VIa. p. 169. 1935; Zycha, Linnemann & Siepmann, Mucorales. p. 148. 1969.; non Pišpek, Acta Bot. Inst. Bot., Zagreb 4: 103. 1929.

Cunninghamella ramosa was accepted by Zycha (1935), Naumov (1939) and Zycha *et al*. (1969), placed in synonymy with *C. echinulata* by Samson (1969) and Lunn & Shipton (1983), excluded by Milko & Beljakova (1967) and Milko (1974), and thought to be doubtful but 'appears closely related to *C. bainieri* (*C. echinulata* var. *verticillata*)' by Cutter (1946). On the basis of the description given by Pišpek (1929), it seems to be more closely related to *C. echinulata* var. *antarctica* according to the irregularly branched sporophores, and especially by the branches which are inflated at the base. Since no type or any other material can be studied, it is treated here as a doubtful species.

EXCLUDED SPECIES

Cunninghamella mandshurica Saito & H. Nagan., Bot. Mag. Tokyo 39: 285. 1913.

≡ *Choanephora mandshurica* (Saito & H. Nagan.) Tai, Sinensia 4: 219. 1934.

Fitzpatrick (1930) pointed out that this fungus was more closely related to *Choanephora* than to *Cunninghamella* owing to its longitudinally striate 'conidia' (sporangiola). Since then, it was excluded from *Cunninghamella* by Tai (1934), Zycha (1935), Naumov (1939), Cutter (1946), Milko & Beljakova (1967), Zycha *et al*. (1969), Samson (1969) and many others. Tai (1934) made the new combination *Choanephora mandshurica* for this species. Zycha *et al*. (1969), Zheng & Hu (as Cheng & Wu, 1964) and Kirk (1984) synonymized both names (*Choanephora mandshurica* and *Cunninghamella mandshurica*) with *Choanephora cucurbitarum* (Berk. & Rav.) Thaxt.

Cunninghamella meineckella A. J. Olson, Phytopathology 131: 1075. 1941.

This species was described by Olson (1941) as a root pathogen of *Pinus*. According to Samson (1969), after the material obtained from the Herbarium of the University of California, Berkeley, was examined, he found that the fungus was identical with the *Oedocephalum* anamorph of *Fomes annosus* (Fr.) Cooke ≡ *Heterobasidion annosum* (Fr.) Brefeld. Milko (1974) also excluded this fungus from *Cunninghamella*.

Cunninghamella microspora (Rivolta) Matr., Ann. Mycol. 1: 56. 1903.

≡ *Gonatobotrys microspora* Rivolta, Dei Parassiti Vegetali. Torino. p. 490. 1873.
≡ *Prachtflorella microspora* (Rivolta) Matr., Ann. Mycol. 1: 56. 1903.

Cunninghamella microspora has been treated variously by different authors. It was placed in *Cunninghamella* by Matruchot (1903), and recognized by Lendner (1908), Zycha (1935), Alcorn & Yeager (1938) and Naumov (1939), considered doubtful by Zycha *et al*. (1969) and Samson (1969), and excluded by Cutter (1946), Milko & Beljakova (1967) and Milko (1974). Cutter (1946) questioned the placement of this fungus as a *Cunninghamella*, and Samson (1969) was doubtful as to whether it was a hyphomycete.

ACKNOWLEDGEMENTS

This project was initiated by a visit of ZRY to CBS in 1995. Studies on the many type or authentic cultures of *Cunninghamella* provided during her stay or sent to her in the later years from CBS formed the basis of this work. Dr D. van der Mei, Director of CBS, is thanked with gratitude for permission to visit and use of the facilities, Dr W. Gams for his kind arrangement and help in every aspect to ensure a successful visit, as well as the many other colleagues for their stimulating discussions made during the stay in CBS. Prof. Song Da-kang, Director of the Beijing-Microbiological Resources Centre, is greatly appreciated for financial support to make the visit possible. Other culture collections like IFO, IMI, MUCL, NHL and NRRL are equally appreciated for supplying cultures used in this study. We are indebted to the many friends and colleagues, either at home or abroad, for their help in various ways by offering us information, literature, samples or cultures. We also thank Ms Zhu Xiang-fei and Ms Yuan Lan-cui respectively for inking the line drawings and printing the micrographs. Special thanks are due to Dr R. P. Korf for his kind consultation on the typification of dried cultures of the heterothallic Mucorales. Our deepest thanks go to Dr G. L. Hennebert and Dr P. M. Kirk for their patience in reviewing the manuscript and for their valuable and helpful comments.

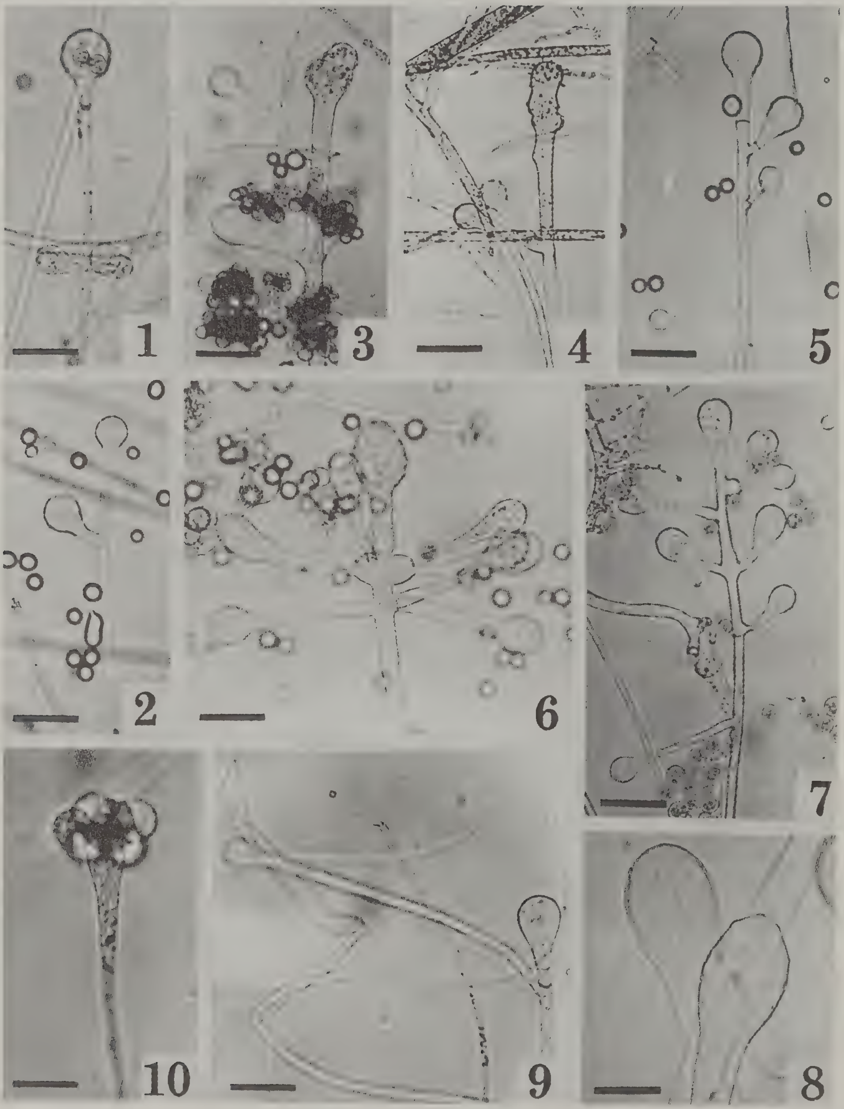

Plate I. Terminal portions of the sporophores showing characteristic branching pattern and shape of the vesicles typical of the following *Cunninghamella* taxa: 1, 2. *C. blakesleeana* (CBS 133.27, T). 3-5. *C. phaeospora* (3. CBS 692.68, NT; 4, 5. Cu-136). 6-8. *C. multiverticillata* (Cu-137 = AS 3.4683, T). 9, 10. *C. homothallica* (IFO 6736, T). [1-7, 9. bar = 50 μm; 8, 10. bar = 20 μm]

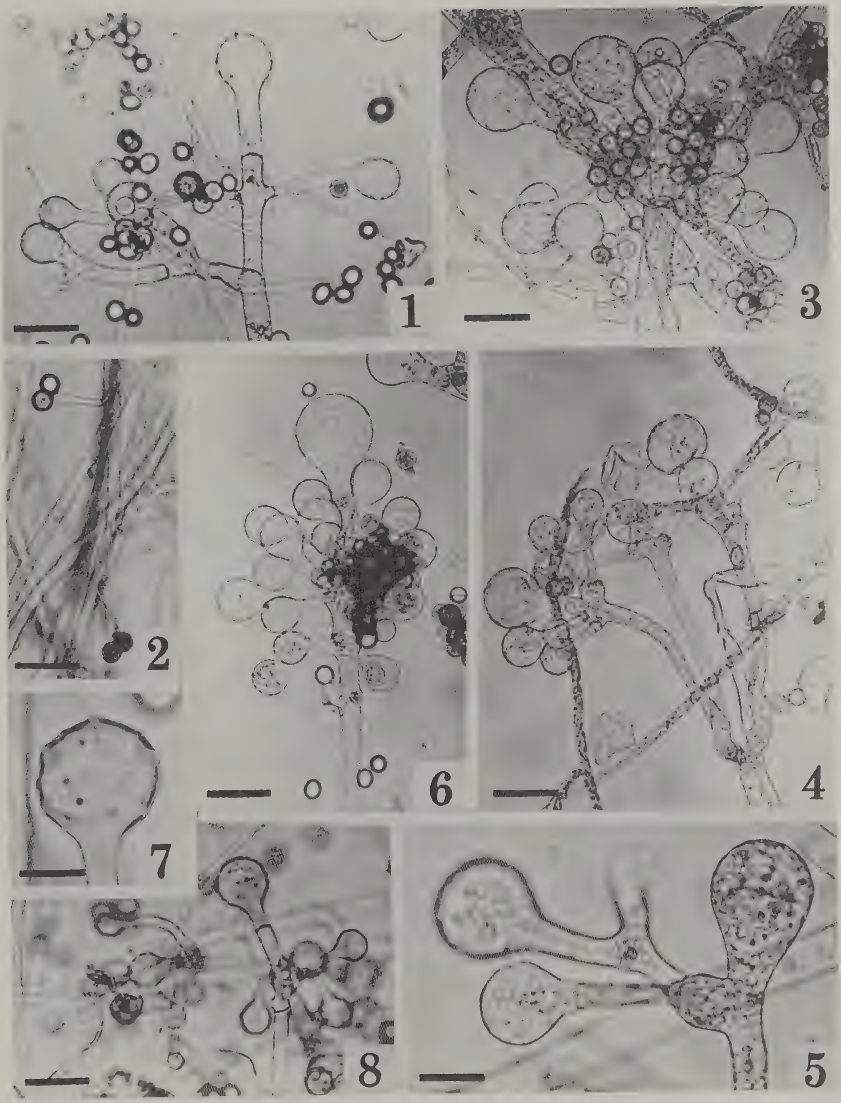

Plate II. Terminal portions of the sporophores showing characteristic branching pattern and shape of the vesicles typical of the following *Cunninghamella* taxa: 1, 2. *C. echinulata* var. *echinulata* (CBS 156.28, NT). 3-5. *C. echinulata* var. *antarctica* (CBS 545.75, T). 6. *C. echinulata* var. *verticillata* (Cu-88). 7, 8. *C. intermedia* (IMI 200623, T). [1-4, 6, 8. bar = 50 μm; 5, 7. bar = 20 μm]

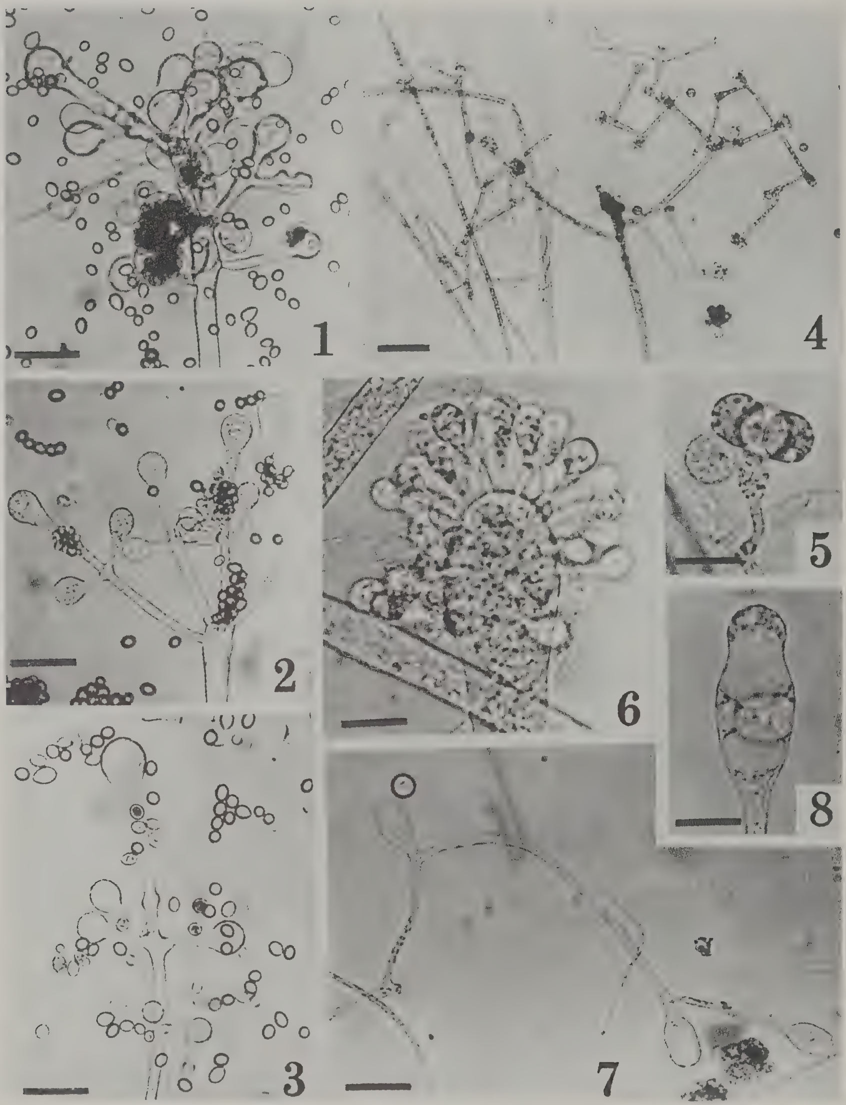

Plate III. Terminal portions of the sporophores showing characteristic branching pattern and shape of the vesicles typical of the following *Cunninghamella* taxa: 1, 2. *C. bertholletiae* (1. Cu-19; 2. NRRL 1380, NT). 3. *C. elegans* (CBS 160.28, NT). 4-6. *C. clavata* (Cu-15 = AS 3.4809, T). 7, 8. *C. vesiculosa* (NRRL 3009, T). [1-3, 7. bar = 50 μm; 4. bar = 100 μm; 5, 6, 8. bar = 20 μm]

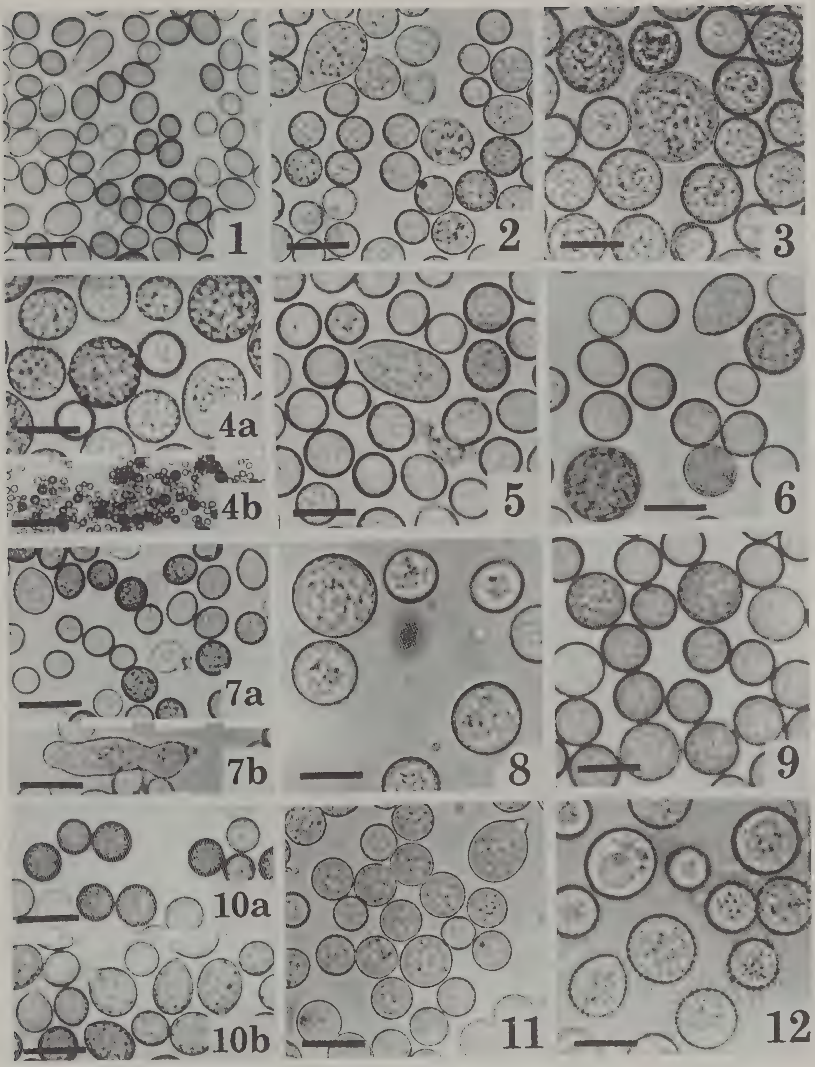

Plate IV. Sporangiola showing shape and dimension typical of *Cunninghamella* taxa: 1. *C. bertholletiae* (NRRL 1380, NT). 2. *C. blakesleeana* (CBS 133.27, T). 3. *C. clavata* (Cu-15 = AS 3.4809, T). 4. *C. echinulata* var. *echinulata* (CBS 156.28, NT. a. from 3-day-old culture; b. from 7-day-old culture). 5. *C. echinulata* var. *antarctica* (CBS 545.75, T). 6. *C. echinulata* var. *verticillata* (CBS 595.68, NT). 7. *C. elegans* (a. CBS 160.28, NT; b. Cu-61). 8. *C. homothallica* (IFO 6736, T). 9. *C. intermedia* (IMI 200623, T). 10. *C. phaeaospora* (CBS 692.68, NT). 11. *C. multiverticillata* (Cu-137 = AS 3.4683, T). 12. *C. vesiculosa* (NRRL 3009, T). [1-3, 4a, 5-12. bar = 20 μm; 4b. bar = 100 μm]

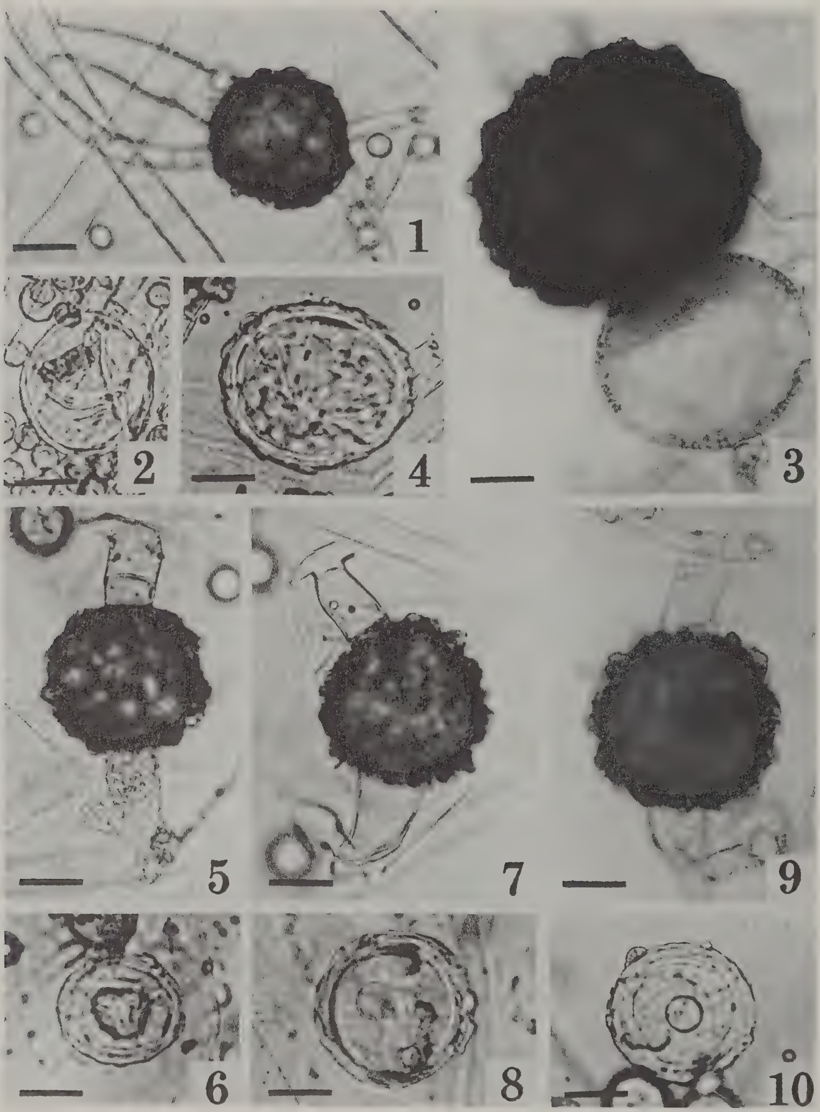

Plate V. Zygosporic characteristics typical of the following *Cunninghamella* taxa: 1, 2. *C. bertholletiae* [1. Cu-19(+) × NRRL 1380(−); 2. Cu-19(+) × Cu-45(−)]. 3, 4. *C. blakesleeana* [3. Cu-89(+) × Cu-53(−); 4. CBS 133.27(+) × Cu-82(−)]. 5, 6. *C. echinulata* var. *echinulata* [5. CBS 156.28(+) × IMI 199844(−); 6. Cu-16(+) × Cu-38(−)]. 7, 8. *C. echinulata* var. *verticillata* [7. CBS 595.68(+) × Cu-22(−); 8. Cu-57(+) × Cu-22(−)]. 9, 10. *C. echinulata* var. *echinulata* × *C. echinulata* var. *verticillata* [9. CBS 156.28(+) × Cu-22(−); 10. Cu-38(−) × CBS 134.27(+)]. [1, 3, 5, 7, 9. Zygosporangia; 2, 4, 6, 8, 10. Zygospores. 1-10. bar = 20 μm]

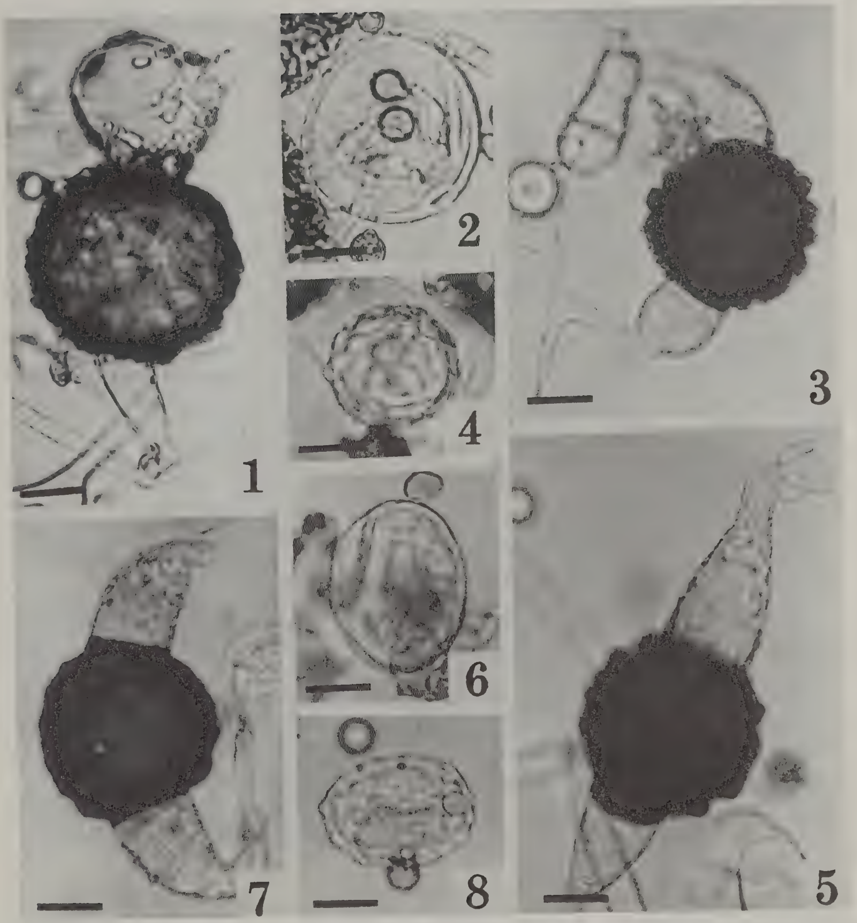

Plate VI. Zygosporic characteristics typical of the following *Cunninghamella* taxa: 1, 2. *C. elegans* [1. Cu-95(+) × IMI 21199(−); 2. CBS 160.28(+) × Cu-2(−)]. 3, 4. *C. homothallica* [IFO 6736(±)]. 5, 6. *C. phaeospora* [CBS 158.28(+) × CBS 159.28(−)]. 7, 8. *C. multiverticillata* × *C. phaeospora* [Cu-137 = AS 3.4683(+) × CBS 692.68(−)]. [1, 3, 5, 7. Zygosporangia; 2, 4, 6, 8. Zygospores. 1-8. bar = 20 μm]

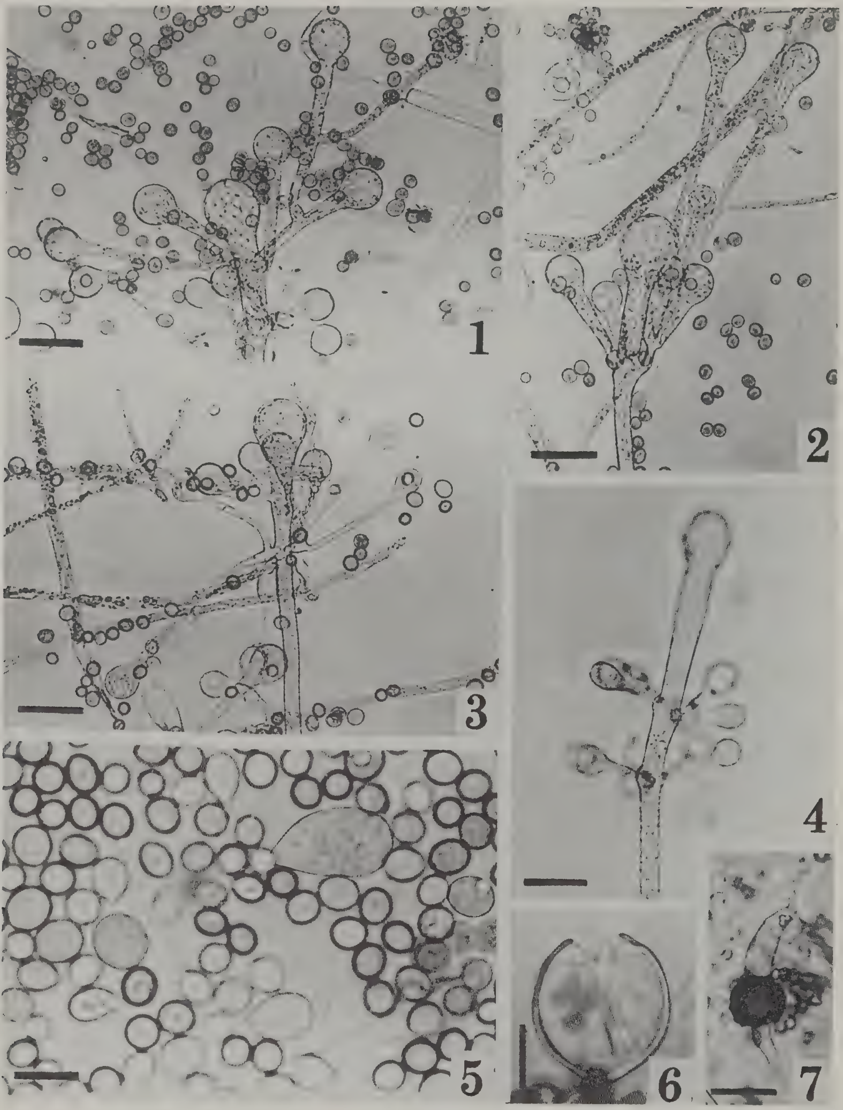

Plate VII. *Cunninghamella binariae* (NRRL 1375, T). 1-4. Terminal portions of the sporophores showing characteristic branching pattern and shape of vesicles. Note that the branches are often typically long and short in the same sporophore and may repeatedly branch several times; the branches are often in pairs and sometimes arise from a common base which may be bulbous or not. 5. Sporangiola which are very variable in sizes. *C. binariae* × *C. bertholletiae* [NRRL 1375(+) × CBS 693.68(−)]. 6. A broken zygospore. 7. A zygosporangium. Note that the suspensors are similar to those of *C. bertholletiae* × *C. bertholletiae*. [1-4, 7. bar = 50 μm; 5, 6. bar = 20 μm]

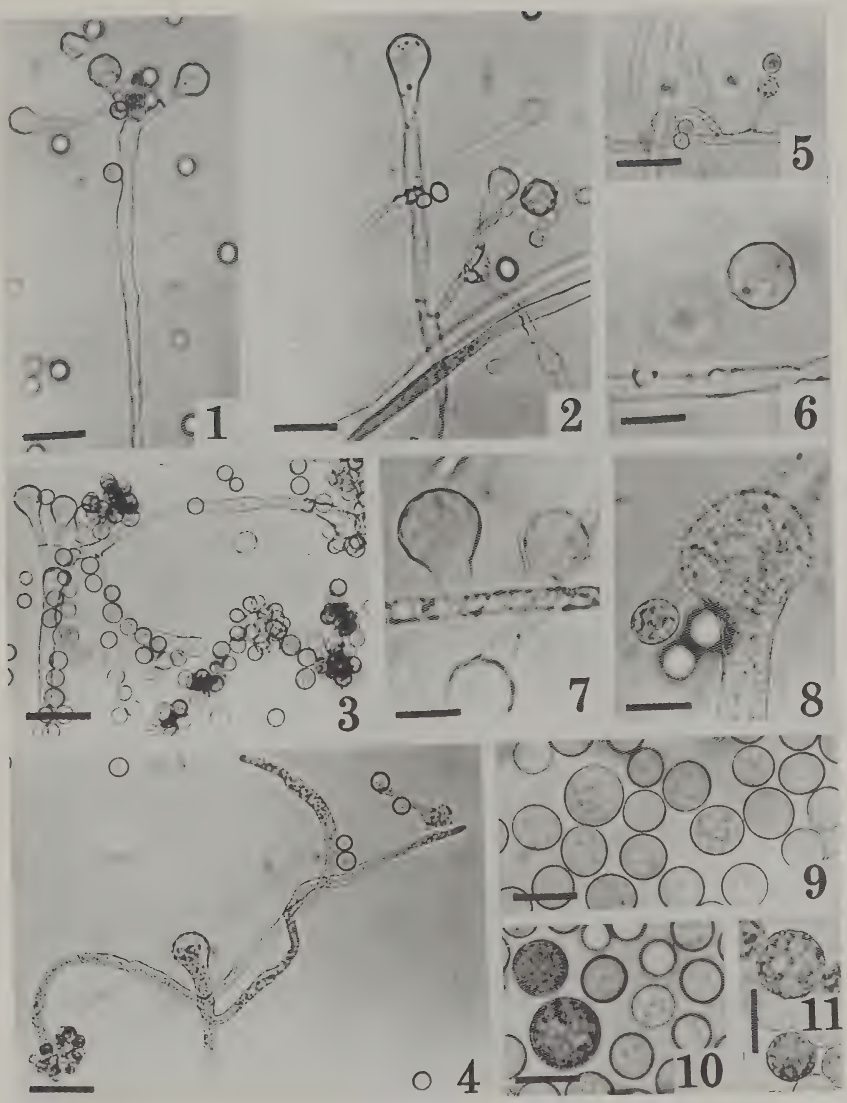

Plate VIII. *Cunninghamella echinulata* var. *nodosa* (Cu-34 = AS 3.5628, T). 1-4. Terminal portions of the longer type sporophores showing characteristic branching patterns. Note that the main axes and branches are typically nodulous and sterile branches sometimes present. 5. Two shorter type sporophores arising from an aerial mycelium. 6. Another shorter type sporophore with an angular vesicle. 7. Angular vesicles from longer type sporophores. 8. Long and slender pedicels on a vesicle. 9. Sporangiola from a 5-day-old culture. 10. Sporangiola with dark giant ones interspersed from a 16-day-old culture. 11. Two tuberculate sporangiospores detached from dark giant sporangiola. [1-5. bar = 50 μm; 6-11. bar = 20 μm]

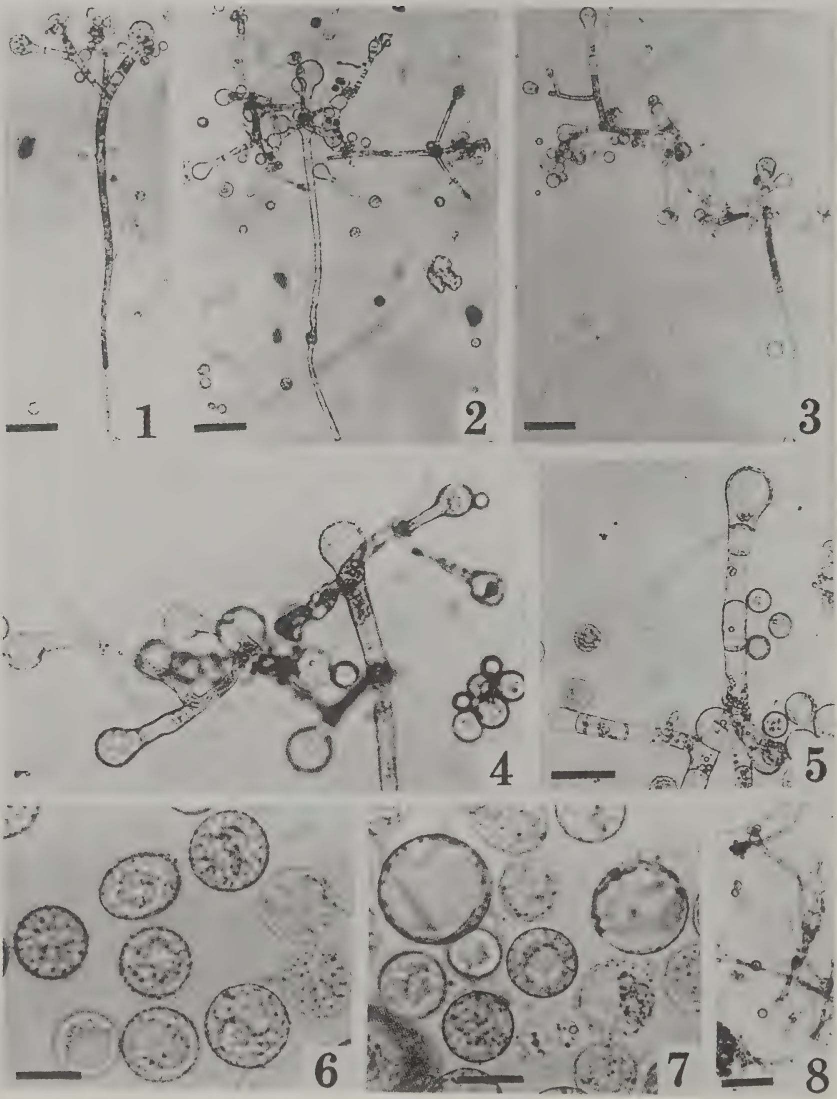

Plate IX. *Cunninghamella septata* (Cu-230 = AS 3.5766, T). 1-4. Terminal portions of sporophores showing characteristic branching patterns. Note that the main axes are broadening upwards, granular, and multi-septate, and the branches often re-branch many times in a zigzag manner. 5. Sporophores from an old culture which are multi-septate and vacuolate. 6. Sporangiola from a one-week-old culture which are mostly granular and spiny. 7. Same, from a two-week-old culture, most of which are vacuolate and becoming larger. 8. Two sporophores arising directly from substrate mycelium. [1-3, 8. bar = 100 μm; 4, 5. bar = 50 μm; 6,7. bar = 20 μm].

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RELATIONSHIPS WITHIN CUNNINGHAMELLA BASED ON SEQUENCE ANALYSIS OF ITS rDNA[*]

LIU Xiao-yong, HUANG He and ZHENG Ru-yong[**]

Systematic Mycology and Lichenology Laboratory
Institute of Microbiology, Academia Sinica
Beijing 100080, China
E-mail: zhengry@sun.im.ac.cn

ABSTRACT

The internal transcribed spacers of ribosomal DNA (rDNA ITS) of 20 strains representing 12 species of the genus *Cunninghamella* were amplified using the polymerase chain reaction (PCR) with a pair of oligonucleotide primers ITS1 and ITS4. The PCR products were cloned and sequenced. The entire lengths of the rDNA ITS region of the 20 strains range from 611 to 844 bp with great differences among species. Generally, sequence analyses provide different values at the strain, variety and species level: genetic distances among strains or varieties of the same species and among different species are respectively less than 0.020, 0.024-0.059, and more than 0.102. In a consensus tree inferred by the neighbor-joining method, although *C. septata* clustered with the 4 varieties of *C. echinulata* in the same clade, and *C. phaeospora* and *C. multiverticillata* formed a clade, they are resolved as systematically distinct species. Results of the other taxa in the present sequence analysis are consistent with morphological studies that support our taxonomic treatments of this genus: all different strains or different varieties of the same species clustered in the same clade; while different species clustered in different clades.

摘要

对小克银汉霉属的 12 个种的 20 株菌的 rDNA ITS 区用 ITS1 与 ITS4 一对引物进行了 PCR 扩增，将 PCR 产物克隆并测序。结果 20 株菌的 rDNA ITS 区长度由 611 至 844 bp 不等，因种而异。序列分析所得遗传距离概括为株间、变种

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[**] Corresponding author.

间与种间三个级别，分别为小于 0.020，0.024-0.059 与大于 0.102。 在用邻近-连接法得出的合意树中，虽然 *C. septata* 与 *C. echinulata* 的 4 株变种聚在同一支内，而且 *C. phaeospora* 和 *C. multiverticillata* 也形成一支，他们在分类上是独立的种。 其他 *Cunninghamella* 的分类群，不同变种，种都聚在各自的分支上。序列分析的结果与形态分类一致并支持我们对该属分类上的处理观点。

INTRODUCTION

As pointed out in the preceding paper (Zheng & Chen, 2001), classification of taxa within *Cunninghamella* differs significantly among different authors. Table 1 of that paper summarizes names of *Cunninghamella* taxa and their taxonomic status as treated by Lendner (1908), Alcorn & Yeager (1938), Naumov (1939), Cutter (1946), Milko & Beljakova (1967), Zycha *et al.* (1969), Samson (1969), Baijal & Mehrotra (1980), Lunn & Shipton (1983), and Zheng & Chen (2001). In addition to the number and names of accepted taxa, treatments of synonymies vary greatly too. No consensus on the classification of *Cunninghamella* has been reached.

Classification of *Cunninghamella* has been based principally on morphology of both the sporangial and zygosporic states, maximum growth temperature, mating compatibility and zygospore formation. In addition, molecular systematics has been used as an important reference for species and variety delimitation, leading to the recognition of 12 species and 3 varieties within the genus. This paper presents our molecular systematic data, while studies on the other aspects are reported in a companion paper (Zheng & Chen, 2001).

Comparative studies of nucleotide sequences of the ribosomal RNA gene provide a means for analyzing phylogenetic relationship over a wide range of taxonomic levels. The internal transcribed spacer (ITS) and intergenic spacer (IGS) regions of the nuclear rDNA repeat units evolve fastest and may vary among species within a genus or among populations within a species (White *et al.*, 1990). The ITS regions have been used in evolutionary studies at the species level for many taxonomic groups of fungi. PCR-RFLPs of the ITS region have been employed to distinguish species and varieties of *Cunninghamella* (Huang *et al.*, 1999). As an exploratory study, sequences of the rDNA ITS2 regions from several problematic species of *Cunninghamella* were sequenced and analyzed recently (Su *et al.*, 1999). In order to obtain more information and to further evaluate their systematic importance to *Cunninghamella*, the entire ITS regions of rDNA of 20 strains representing 12 species were sequenced and analyzed. Results obtained support those from the ITS2 and provide additional genetic data on variation within the ITS1. They also are concordant with morphological studies, and support our published taxonomic treatments (Zheng & Chen, 1992, 1994, 1996, 1998, 2001).

MATERIALS AND METHODS

Strains and culture conditions

Strain data for the *Cunninghamella* strains used in this study are listed in Table 1. Seventeen of the 20 strains are ex-types (T) or neotypes (NT). *Mucor hiemalis* f. *luteus* CBS 244.35 served as outgroup in the phylogenetic analyses. All stock cultures were maintained on potato dextrose agar (PDA). In order to obtain sufficient mycelial mass for DNA, a 50 ml glucose-asparagine-thiamine synthetic medium (Huang & Yu, 1988) in a 250 ml Erlenmeyer flask was inoculated with a one-week old slant culture. After incubating for 3-4 days at 28℃ at 200 rpm on a G24 environmental incubator shaker (New Brunswick Scientific Co., U.S.A.), mycelia were collected by vacuum filtration, washed three times with sterile distilled water and once with 25% ethanol, dried with sheets of sterile filter paper and then frozen at -20℃ for DNA extraction.

DNA extraction

The extraction procedure follows a published CTAB method (Rogers & Bendich, 1988) with some modifications. About 75 mg of dried mycelia of each strain was ground in liquid nitrogen to a fine powder. The ground mycelia were transferred to a 1.5 ml microfuge tube and 0.63 ml of 65℃ 1×CTAB extraction buffer, containing 1% CTAB, 50 mM Tris (pH 8.0), 20 mM EDTA (pH 8.0), and 0.7 M NaCl, was added. The mixture was shaken vigorously and then heated for 10 min in a 65℃ water bath. After a series of deproteinizations with chloroform-isopropyl alcohol (24:1 in volume), the supernatant was treated with a final concentration of 0.1 mg ml^{-1} RNase, 1 mg ml^{-1} Pronase and 1 mg ml^{-1} α-amylase for 1 h at 37℃ with each enzyme, and deproteined again. After adding sodium acetate (pH 4.8) to a final concentration of 0.3 M, two volumes of cold absolute ethanol were added to precipitate the DNA. The precipitated DNA was pelleted in a centrifuge, washed and dried, dissolved in 50 μl sterile distilled water and stored at -20℃ until PCR amplification.

PCR amplification

The nuclear rDNA region, containing the internal transcribed spacers ITS1 and ITS2 as well as the 5.8S rDNA region, was amplified

Table 1. *Cunninghamella* and *Mucor* strains used in the study

Species	Strain	Substrate	Origin	Reference	GenBank Acc. No.
C. bertholletiae Stadel	NRRL 1380 (NT)	Brazil nut	U.S.A.	Blakeslee *et al.*, 1921	AF254930
C. bertholletiae	CBS 693.68	Soil	Yugoslavia	Samson, 1969; received as NT of *C. polymorpha* Pišpek	AF254931
C. binariae R. Y. Zheng	NRRL 1375 (T)	Brazil nut	U.S.A.	Zheng & Chen, 2001; received as *C. bertholletiae*	AF254935
C. blakesleeana Lendn.	CBS 133.27 (T)	Brazil nut	U.S.A.	Lendner, 1927	AF254932
C. clavata R. Y. Zheng & G. Q. Chen	Cu-15 (T)	Faded flower	Guiyang, Guizhou	Zheng & Chen, 1998	AF254942
C. echinulata (Thaxt.) Thaxt. ex Blakeslee var. *echinulata*	CBS 156.28 (NT)	Air	U.S.A.	Blakeslee *et al.*, 1921	AF254936
C. echinulata var. *antarctica* (Caretta & Piont.) R. Y. Zheng & G. Q. Chen	CBS 545.75 (T)	Hair baited soil	The Antarctic Continent	Caretta & Piontelli, 1977; received as *C. antarctica* Caretta & Piont.	AF254938
C. echinulata var. *nodosa* R. Y. Zheng	Cu-34 (T)	Faded flower	Beijing	Zheng & Chen, 2001	AF346407
C. echinulata var. *verticillata* (F. S. Paine) R. Y. Zheng & G. Q. Chen	CBS 595.68 (NT)	Peas	Canada	Cutter, 1946; received as *C. bainieri* Naumov	AF254937
C. elegans Lendn.	CBS 160.28 (T)	Soil	U.S.A.	Blakeslee *et al.*, 1921	AF254928
C. elegans	MUCL 16087	Fish flour	Belgium	Zheng & Chen, 2001; received as *C. blakesleeana*	AF346409
C. elegans	Cu-2	Garden soil	Shennongjia, Hubei	Zheng & Chen, 2001	AF254927
C. elegans	Cu-95	Dried apricot	Xiaowutai, Hebei	Zheng & Chen, 2001	AF254929
C. homothallica Komin. & Tubaki	IFO 6736 (T)	Soil	Japan	Kominami *et al.*, 1952	AF254941
C. intermedia K. B. Deshp. & Mantri	IMI 200623 (T)	Soil	India	Deshpande & Mantri, 1966	AF254939
C. intermedia	CBS 347.69	Soil	India	Rai *et al.*, 1968; received as T of *C. brunnea* J. N. Rai *et al.*	AF254940
C. multiverticillata (R. Y. Zheng & G. Q. Chen) R. Y. Zheng	Cu-137 (T)	Forest soil	Shennongjia, Hubei	Zheng & Chen, 1994; formerly as *C. phaeospora* var. *multiverticillata* R. Y. Zheng & G. Q. Chen	AF254933
C. phaeospora Boedijn	CBS 692.68 (NT)	Soil	Indonesia	Samson, 1969	AF254934
C. septata R. Y. Zheng	Cu-230 (T)	Mixed culture	Belgium	Zheng & Chen, 2001	AF346408
C. vesiculosa P. C. Misra	NRRL 3009 (T)	Forest soil	India	Misra, 1966	AF254943
Mucor hiemalis Wehmer f. *luteus* (Linnem. ex K. Q. Pei) Schipper ex K. Q. Pei	CBS 244.35 (T)	—	Germany	Pei, 2000, 2001	AF254944

Source: Centraalbureau voor Schimmelcultures, Netherlands (CBS); Culture Collection of the Systematic Mycology & Lichenology Laboratory (with a Cu- prefix for *Cunninghamella* spp.); Institute for Fermentation, Osaka, Japan (IFO); CABI Bioscience (formerly International Mycological Institute), United Kingdom (IMI); Agricultural Research Service Culture Collection, United States of America (NRRL).

by PCR using the forward primer ITS1 and the reverse primer ITS4 (White *et al.*, 1990). A serial dilution of genomic DNA was used to optimize the concentration of template for the PCR amplification. The PCR was performed in a 50 μ l reaction mixture containing dilute genomic DNA in optimum concentration, 0.5 μ M of each primer, 10 mM Tris-HCl (pH 8.0), 50 mM KCl, 0.08% Nonidet P40, 1.5 mM magnesium chloride ($MgCl_2$), 200 μ M each of nucleotide triphosphate (Promega Co., U.S.A.), and 2 units *Taq* DNA polymerase (Sangon Ltd., Canada). Mineral oil (40 μ l) was overlaid on the reaction mixture. The reaction was performed in a MiniCycler^{TM} (MJ Research Inc., U.S.A.) for 35 cycles: denaturation at 93℃ for 1 min, annealing at 52℃ for 50 sec, extension at 72℃ for 1 min and 20 sec, with an initial denaturation at 94 ℃ for 1 min before cycling and final extension at 72℃ for 10 min after cycling. An aliquot (2 μ l) of the PCR amplification product was electrophoresed in a 1.0% agarose gel, stained with ethidium bromide (EtBr) and visualized over ultraviolet light. The PCR amplification product was purified directly from the remainder of the PCR amplification reaction mixture using the Wizard^{TM} PCR Preps DNA Purification System (Promega Co., U.S.A.) according to the instructions of the manufacturer. Purified amplification products were stored at -20℃ until cloning and sequencing.

Cloning and sequencing

For cloning of the ITS region, the purified amplification product was ligated directly into the *Eco*R V site of the pBluescript SK II+ T-vector which was constructed following the procedures of Marchuk *et al.* (1991). The recombinant phagemid was used to transform competent cell of strain TG1 of *Escherichia coli* prepared with calcium chloride. Recombinant colonies were identified by blue/white selection after overnight culture at 37℃ on SOB solid medium, supplemented with IPTG, X-Gal and ampicillin. Small-scale phagemid DNA was prepared using the method of lyses by alkali. The presence of cloned inserts was verified by digestion with *Pvu* II. Cloned PCR products were sequenced by the dideoxy-chain-termination method of Sanger (Sambrook *et al.*, 1989) with the T7 Sequencing^{TM} Kit (Amersham Pharmacia Biotech Inc., Sweden) following the protocols supplied by the manufacturer. Primers SK (5'-TCT AGA ACT AGT GGA TC-3') and KS (5'-CGA GGT CGA CGG TAT CG- 3') complementary to phagemid pBluescript II SK+, which were synthesized by Sino-American Biotech Co., China, were used for sequencing the double stranded DNA. [α-^{35}S]dATP (Du Pont Co. Boston, U. S. A.) was used for radiolabel. A few cloned

PCR products of Cu-34, Cu-230 and MUCL 16087 were sequenced in an Applied Biosystems 377 sequencer by GeneCore Biotechnologies.

DNA sequence alignments and analyses

Sequences were aligned using the computer program CLUSTAL_X 1.64b (Thompson *et al.*, 1997) and the final multiple alignment was calculated by the program DNADIST within the Phylogeny Inference Package (PHYLIP) version 3.5c (Felsenstein, 1993) to obtain a pairwise distance matrix following the Kimura two-parameter model of nucleotide substitution. Alignment gaps were treated as missing data. A consensus tree was generated by TREECON for Windows (Van de Peer & De Wachter, 1994) using the Kimura evolutionary model and neighbor-joining method with 1000 bootstrap replicates to estimate the robustness of the internal nodes of the tree.

RESULTS AND DISCUSSIONS

DNA sequence alignments

The ingroup consisted of complete sequences of rDNA ITS region of 20 strains of *Cunninghamella* while a sequence of *Mucor hiemalis* f. *luteus* (Pei, 2001) was selected as an outgroup. All of the sequences in this study have been deposited in GenBank under accession numbers given in Table 1 and are aligned in Fig. 1. Boundaries of the SSU (small subunit), ITS1, 5.8S, ITS2 and LSU (large subunit) of rDNA were determined by comparison with published sequences (Schaak *et al.*, 1982). When comparing the alignments, the 3' end of the SSU rRNA gene (sites 1 to 30 in Fig. 1) of the 20 strains are identical, whereas the 5' end of the LSU rRNA gene (sites 1003 to 1063 in Fig. 1) vary at 17 sites, including deletions and insertions, among species of *Cunninghamella.* Sequences of the 5.8S rDNA are highly conserved throughout the species. Both length and nucleotides of the ITS region are highly variable among different species (Table 2). The entire ITS lengths varied among species by as much as 233 bp, from 611 bp for *C. homothallica* IFO 6736 to 844 bp for *C. septata* Cu-230. The ITS1 region varies in length by 100 bp (from 228 to 328 bp in length) and ITS2 by 229 bp (from 199 to 428 bp in length). The 4 varieties of *C. echinulata* have an insertion within the ITS2 region up to 156 bp (sites 649 to 804 in Fig.1). A number of variable sites were evident in ITS1 and ITS2 regions: 224 sites for ITS1 and 176 for ITS2 (Fig. 1). Hence, it is very useful for the systematic studies of *Cunninghamella* to compare the site and length variations of the rDNA ITS region.

```
                1        10         20         30         40         50         60
CBS 545.75      TCCGTAGGTG AACCTGCGGA AGGATCATTA ACTATTTAAA GGGGAATAAG GCTTTAAAAA
Cu-34           .......... .......... .......... .......GT- .......... ..........
CBS 156.28      .......... .......... .......... .......GT- ........-. ..........
CBS 595.68      .......... .......... .......... .......GTG ......GT.T T..A.TCG..
Cu-230          .......... .......... .......... .......GT- .......... ..........
CBS 160.28      .......... .......... .......... CT....CGGT CATTGG.TTT TA..C.....
Cu-95           .......... .......... .......... CT....CGGT CATTGG.TTT TA..C.....
Cu-2            .......... .......... .......... CT....CGGT CATTGG.TTT TA..C.....
MUCL 16087      .......... .......... .......... CT....CGGT CATTGG.TTT TA..C.....
NRRL 1380       .......... .......... .......... CA...G-GGT CAAA.GA.TA .T..G....G
CBS 693.68      .......... .......... .......... CA....-GGT CAAA.GA.TA .T..G.....
Cu-137          .......... .......... .......... C....C.GGG .TCATG.TT. TT....TC..
CBS 692.68      .......... .......... .......... CT...-.GGG AAAATCATT. AGG----C..
CBS 133.27      .......... .......... .......... CT......TT .A.AG.A.GA .AG.C-TCCT
Cu-15           .......... .......... .......... TGA..--G.T TATTTT.GG. .GG.GT....
NRRL 1375       .......... .......... .......... CT....--TT .AA.TT.TT. AAAA.TTT.T
IFO 6736        .......... .......... .......... CT.....-TT .ATCTC.--C TTAGAG.TC.
IMI 200623      .......... .......... .......... .....GCGGT ...AG----. A.CCC-----
CBS 347.69      .......... .......... .......... .....GCGGT ....G.G.C. A.CCC-----
NRRL 3009       .......... .......... .......... .....AGGT. TA.A.TG.CC AGCGGG.TT.
CBS 244.35      .......... .......... .......... .A..A..-TT .AA.GC.GGC CTCCGGGTC.

                         70         80         90        100        110        120
CBS 545.75      -CCTTTT--- -TCACCATT- ---AATTCAT CCATAATGTG G-----GTCA AACCA-----
Cu-34           .......... .......... .......... .......... .......... ..........
CBS 156.28      .......... .-........ .......... .......... .......... ..........
CBS 595.68      .T....-... .-........ .......... .....G.... .......... ..........
Cu-230          A......... .......... .......... .......... .......... ..........
CBS 160.28      C.-----... ..TTGGC..T .....A.... ...C.G.... .GAAAT...T TCTA-....A
Cu-95           C.-----... ..TTGGC..T .....A.... ...C.G.... .GAAAT...T TCTA-....A
Cu-2            C.-----... ..TTGGC..T .....A.... ...C.G.... .GAAAT...T TCTA-....A
MUCL 16087      C.-----... ..TTGGC... .....A.T.. ...C.G.... .GAAAT...T TCTA-....A
NRRL 1380       GG..A..TTT T.T-GAC... ..A..C.T.. ...C.G.... .GAAAT...T TCTA-....A
CBS 693.68      GG..A..TTT T.TTGAC..T AAA..C.T.. ...C.G.... ..AAAT...T TCTA-....A
Cu-137          AA....C... ..TTGGC..T .....A.T.. ...C.G.... ..AAAT.... GC.A-....A
CBS 692.68      CT..C.GA.. ..TTTTC..T .....A.... ...C.G.... .GAAAT...T TTTA-....A
CBS 133.27      CT..C.C... ...T.A...A ..A..A.... ...C.G.... .GAAAT...T TT.ATTTAAA
Cu-15           AG.C..C... ..T-AA..AA TAA..ACT.. ...C.G.... .GAAAA.... TT.A-...AT
NRRL 1375       CGT...CATT ..ACTTC.AA ACA.CA.... ...C.G.... .GAAAT...T TTAT-....A
IFO 6736        ATAA---... .-----.A.. ...C..C..C AGTGTGG.-- -.AAAT...T TCTT.....A
IMI 200623      .------... .-----..GG TAGC.A.GC- -...GG...T TG....-.TT TC.T.CTCAT
CBS 347.69      .------... .-----..GG TAGC.A.GC- -...GG...T TTG..TT.TT TC.T.CTCAT
NRRL 3009       .------... .-----..GT TGG.GA.TGA T..GGGG.GA AAA..G...T TTTACCCAAA
CBS 244.35      CG..---... .-----C... ...CTA.A.. TT.CTG..-- -.AACT..AT T.TT-.....

                        130        140        150        160        170        180
CBS 545.75      C--ATGCGCA ATGTT----- ---TTTTTTT -T----AAAG GGTTAAC--- ------TTTC
Cu-34           .......... .......... .......... .-........ .......... ..........
CBS 156.28      .......... .......... ......A--- .-........ .....-.... ..........
CBS 595.68      .......... .......... .......... ..TTAA..G. ..G.T..... ..........
Cu-230          .......... .......... .......... .-........ .......... ..........
CBS 160.28      .GCT..T..C TG...CA.GT .C..AG.GC. .GCCACTTGA .T...CT... ......C..G
Cu-95           .GCT..T..C TG...CA.GT .C..AG.GC. .GCCACTTGA .T...CT... ......C..G
Cu-2            .GCT..T..C TG...CA.GT .C..AG.GC. .GCCACTTGA .T...CT... ......C..G
MUCL 16087      .GCT..T..C TG...CA.GT .C..AG.GC. .GCCACTTGA .T...CT... ......C..G
NRRL 1380       .GCT..T..C TG...CA.GT .C..AG.GC. .GCCACTTGA .T...T.... ......C..A
CBS 693.68      .GCT..T..C TG...CA.GT .C..AG.GC. .GCCACTTGA .T...T.... ......C..A
Cu-137          .GCT.AT..C TG...CA.GT .CA..G.GC. .GCCACTTGA .T...TT... ......CA.T
CBS 692.68      .GCT..T..C TG..ACA.GT .CT.AG.GC. .GCCACTTGA .T...T.... ......C..A
CBS 133.27      .GCC..T..C TG..ATA.GT .C..AG.GC. .ACCACTTGA .T...T.... .........T
Cu-15           .GCT..T..C TG....A.GT .CA..GAGC. .AGCCCCC.A .T...C.TAG GATGTAC...
NRRL 1375       .GCT..T..C TG...CA.GT .CA..G.GC. .GCCAC.GGA .T...CT... ......-..A
IFO 6736        .GCT..T..C TG...CA.GT CATA.G.AC. .GCCACTTGT .T...TTCTT ......-AGA
IMI 200623      TTC..C--.. CCC..TT.GT GCAC.G.C.. ..ATTT.TCA .TC.TG.AC. ......CGCA
CBS 347.69      TTC..C--.. CCC..TTTGT GCAC.G.C.. ..ATTC.TCA .TC.TG.AC. ......CGCA
NRRL 3009       ATAC.CGT.. CACAAAAAGT GAACCGAG.. G.ACCC...C .AA.--.CT. ......GGC.
CBS 244.35      -..T.CT.GC -GT..GA.G. .AAA.G.CC. .GC...---T ..C..TAAGG ......-A.A
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                     190        200        210        220        230        240
CBS 545.75    GGGTT----A CTCTTTATTT ATT------- -ATAATATGG CC-------- ----------
Cu-34         .......... .......... ...T...... .......... .......... ..........
CBS 156.28    ....-..... ......T... .......... .......... TTC....... ..........
CBS 595.68    ....-..... ......T... TA.T...... .......... .......... ..........
Cu-230        .......... .......... ...T...... .......... ..TA...... ........AA
CBS 160.28    ..TCA.AGGG AC....GGG. .G.T...... .-.GT.CAT- --........ ..........
Cu-95         ..TCA.AGGG AC....GGG. .G.T...... .-.GT.CAT- --........ ..........
Cu-2          ..TCA.AGGG AC....GGG. .G.T...... .-.GT.CAT- --........ ..........
MUCL 16087    ..TCA.AGGG AC....GGG. .G.T...... .-.GT.CAT- --........ ..........
NRRL 1380     .ATCA.AGGG A.....GGG. .G.TGTTCAT T..TT.C.CT .TCTCTCTCT CTCTTTTTAG
CBS 693.68    .ATCA.AGGG A.....GGG. .G.TGTTCAT T..TT.C.C- --.......T CTCTTTTTAG
Cu-137        A.TCA.AGGG ACT...GGG. .G.TTTTTTT TT.TT.T.T- --........ .....TTTAA
CBS 692.68    A.TCA.AGGG A.T...GGG. .G.TGTTTTT TT.TT.T.T- --........ .....TTTTT
CBS 133.27    A.TCA.ATGG ACT....GA. .G.GCTT... .-.TT.CCT- --........ ..........
Cu-15         CTT.G.TAGG A.T...CGG. .GAGAGTTTT GGAG.A.GAT TTCGTAAGAT TTCCATTTTG
NRRL 1375     .ATCATAAGG G......GC. .G.T...... .--TTCCGT- --........ ..........
IFO 6736      TCAAG..GG. TCT..G.G.A G--....... .-.TT.CA.- --........ ..........
IMI 200623    A.CACACCTG AA.C..GG-- .CCATGATCA ATGGTC-ATT GGGCCTCTTG GTCTTTGGGA
CBS 347.69    A.CACACCTG AA.C..GG-- .CCATGATCA ATGGTCCATT GGGCCTCTTG G.........
NRRL 3009     ATCCCAACTG A.GG...CCC .CCGGGAAGG TC..GC.AA. GTACCTAGTA CTCTTTTATA
CBS 244.35    -----...GG .CTGG..GGA .--....... .-.GT..A-- --........ ..........

                     250        260        270        280        290        300
CBS 545.75    ---------- ---------- ---------- ----TAAAA- -AACCATATT ATT---AATT
Cu-34         .......... .......... .......... .......... .......... ..........
CBS 156.28    .......... .......... .......... ..TT.TTTG. .GG.T..... ..........
CBS 595.68    .......... .......... .......... .......... .......... ..........
Cu-230        AAACCATATT TTTTTTTTTT TTTGTA.TTT AATC...... .......... ..........
CBS 160.28    .......... T....CGTGA ..GCAA.CCT CTTG.-..C. .GGGG...AG ..........
Cu-95         .......... T....CGTGA ..GCAA.CCT CTTG.-..C. .GGGG...AG ..........
Cu-2          .......... T....CGTGA ..ACAA.CCT CTTG.-..C. .GGGG...AG ..........
MUCL 16087    .......... T....CGTGA ..GCAA.CCT CTTG.-..C. .GGGG...AG ..........
NRRL 1380     GGGGGGGGGA AGATTAATGA TGGGCA.CCT CTTG.-.... .GGG-...AG .......C..
CBS 693.68    GGGGGGGG.. AGATTAATGA TGGGCA.CCT CTTG.-.... .GGGG...AG .......C..
Cu-137        ..A.....AA AAAAAAAAAA AAAAAA.CCT CTTG.-.... .GGGG...AG ...T...C..
CBS 692.68    ..G.....AA TTAAAAAAAA ACAA...CCT CTTG.-.... .GGGG...AG ...T...C..
CBS 133.27    .......... ...TGGAAGA T.AGCA.CCT CTTG.-...A .GGGG...AG ...T..C...
Cu-15         AAAAAAT..T TTTTAATTGA AAAAGA.CCT TGGG.T...A .TGGG...AG .A-.......
NRRL 1375     .......... .........T AGGAAA.CCT TCTG.-...A .GGGG...AG ...TTTTT..
IFO 6736      .......... .......... .........T AATGA...CC TCTTGTA.AG GGGA..C.AG
IMI 200623    CCTCGGGTTC TAAGGAGACA TAGGGAACTT TTGGGTTC-T GGTG.GG... GA.ACACC..
CBS 347.69    .CTC...... .......... .........T TTGGGTTC-T GGTG.GG... GA.ACACC..
NRRL 3009     GGGGAAAGGA ACTGGAG.CA GGACTAGCCT GTGGGTGG.T AGGGA.G..C GCAATAT...
CBS 244.35    .......... .......... .........T CGAG.C.G.G TC.GGC.TAG G--...CC.G

                     310        320        330        340        350        360
CBS 545.75    TTT-TTATAC TAAATTT--- ----ACTGAA TAAA-CGATT GA-CCATA-A TTTATGGTTG
Cu-34         .......... .......... .......... .......... .......... ..........
CBS 156.28    .......... .......... ......C... ...-...... .......... ..........
CBS 595.68    .......... .......... .......... .......... .......... ..........
Cu-230        .......... .......... .......... .......... .......... ..........
CBS 160.28    ..A....... .......T.. .......... CT--.-...A ........A. .C........
Cu-95         ..A...T... .......T.. .......... CT--.-...A ........A. .C........
Cu-2          ..A....... .......T.. .......... CT--.-...A ........A. .C........
MUCL 16087    ..A....... .......T.. .......... CT--.-...A ........A. .C........
NRRL 1380     ..A...G... .......T.. .......... CT--.-...A ........A. .C........
CBS 693.68    ..A....... .......T.. .......... CT--.-...A ........A. .C........
Cu-137        ..A.A..... .T.T...A.. .......... CT--.-...A ........A. .C........
CBS 692.68    ..A....... .T.T...A.. .......... CT--.-...A ........A. .C........
CBS 133.27    ..A....... .TTT...TTT TTTA...... CT--.-...A ........A. .C........
Cu-15         ....A..... ..TT...TTT TTTT...A.. ATT-.....A .G....A.AG ...T......
NRRL 1375     ..A....... .TTT...TTA TT........ CT--.-...A ........A. .C........
IFO 6736      A....AC.TT ..TTA.AC.. ...TTT.A.C .---.-.--A AC.TG...G. C-C..AAA.C
IMI 200623    ..-....... ..-.A..A.. ...T...... A.T-.-.... ........AT -----.....
CBS 347.69    ..-....... ..-.A..A.. ...T...... A.T-.-.... ..A.....AT A---......
NRRL 3009     ..AC...GCA ..C.A.GA.. ...A...... CTTTAA.... ...A....A. ------.G..
CBS 244.35    G.A..CC..T ..TTA..... ...T..CA.. A---.-.--A AT.T..GT.. .-...AA...
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                    370        380        390        400        410        420
CBS 545.75   TTTTAAAAAT ATATTAATTT ATAT----AA AAACAACTTT CAGCAATGGA TCTCTCGGCT
Cu-34        .......... .......... .......... .......... .......... ..........
CBS 156.28   ...-...... .......... .......... .......... .......... ..........
CBS 595.68   .......... .......... .......... .......... .......... ..........
Cu-230       .......... .......... .......... .......... .......... ..........
CBS 160.28   ....TT-.T. ...A----AC .A.-....-. .......... .......... ..........
Cu-95        ....TT-.T. ...A----AC .A.-....-. .......... .......... ..........
Cu-2         ....TT-.T. ...A----AC .A.-....-. .......... .......... ..........
MUCL 16087   ....TT-.T. ...A----AC .A.-....-. .......... .......... ..........
NRRL 1380    ....TT-.T. ...A.T.AAC .A.AAAAA.. .......... .......... ..........
CBS 693.68   ....TT-.T. ...A.T.AAC .A.-....-. .......... .......... ..........
Cu-137       ....TTT.T. ...A--.AAA .A.AA..... .......... .......... ..........
CBS 692.68   ....TT---- ...A--TAAA .A..T..... .......... .......... ..........
CBS 133.27   ....TT-.T. ...A----AA .A..T..... .......... .......... ..........
Cu-15        ....T.---- .A.A--T.A. .A..TTC... .......... .......... ..........
NRRL 1375    ....TTTTT. ....A.TAA. .A.ATTT... .......... .......... ..........
IFO 6736     .A.GGTTGT. T.TA.--.AA .ACC...... .......... .......... ..........
IMI 200623   ...AT.-.TA ...A------ -A.-....-. ........G. .......... ..........
CBS 347.69   G..ATT-.TA ...A.----- .A.-....-. .......... ....G..... ..........
NRRL 3009    .A.AT----- ...A------ ----....-- .......... .......... ..........
CBS 244.35   .AAC.T..GC G..A----AA .AC.TAT... .......... T.A...C... .....T..T.

                    430        440        450        460        470        480
CBS 545.75   TTCGTATCGA TGAAGAACGC AGCAAATCGC GATATTTAAT GTGATCTGCC TAT-AGCGAA
Cu-34        .......... .......... .......... .......... .......... ......T...
CBS 156.28   .......... .......... .......... .......... .......... ......T...
CBS 595.68   .......... .......... .......... .......... .......... ......T...
Cu-230       .......... .......... .......... .......... .......... ......T...
CBS 160.28   .......... .......... .......... .....G.... .......... ......T...
Cu-95        .......... .......... .......... .....G.... .......... ......T...
Cu-2         .......... .......... .......... .....G.... .......... ......T...
MUCL 16087   .......... .......... .......... .....G.... .......... ......T...
NRRL 1380    .......... .......... .......... .....G.... .......... ......T...
CBS 693.68   .......... .......... .......... ...G.G.... .......... ......T...
Cu-137       .......... .......... .......... ...G.G.... .......... ......T...
CBS 692.68   .......... .......... .......... .....G.... .......... ......T...
CBS 133.27   .......... .......... .......... ...G.G.... .......... ......T...
Cu-15        .......... .......... .......... .....G.... .......... ......T...
NRRL 1375    .......... .......... .......... .G...G.... .......... ......T...
IFO 6736     .......... .......... .......... .....G.... .......... ......T...
IMI 200623   .......... .......... .......... .......... .......... ......T...
CBS 347.69   .......... .......... .......... .......... .......... ......T...
NRRL 3009    .......... .......... .......... .......... .......... ......T...
CBS 244.35   C...C..... .........T ......GT.. ....AC..G. ....AT...A ...C..T...

                    490        500        510        520        530        540
CBS 545.75   TCATCAAATC TTTG-AACGC ATCTTGCACC CTATGGTAT- TCCGTAAGGT ACATCTGTTT
Cu-34        .......... .......... .......... .......... ......-... ..........
CBS 156.28   .......... .......... .......... .......... ......G... ..........
CBS 595.68   .......... .......... .......... T......... ...A...... ..........
Cu-230       .......... .......... .......... .......... ......G... ..........
CBS 160.28   .......... .......... .......... T......... ...A...... ..G.......
Cu-95        .......... .......... .......... T......... ...A...... ..G.......
Cu-2         .......... .......... .......... T......... ...A...... ..G.......
MUCL 16087   .......... .......... .......... T......... ...A...... ..G.......
NRRL 1380    .......... .......... .......... TC........ ...A...... ..G.......
CBS 693.68   .......... ....G..... .......... TC........ ...A...... ..G.......
Cu-137       .......... ....G..... .......... T......... ...A...... ..G.......
CBS 692.68   ...CA..... ....A..... .......... T......... ...A...... ..G.......
CBS 133.27   .......... ....G..... .......... T......... ...A...... ..G.......
Cu-15        .......... .......... .......... T.......C. ...A...... .-G.......
NRRL 1375    .......... .......... .......... T......... ...A...... ..G.......
IFO 6736     .......... .......... .......... .......... ...A...... ..G.......
IMI 200623   .......... .......... .......... T......... ...A...... ..........
CBS 347.69   .......... .......... .......... T....A.... ...A...... ..........
NRRL 3009    .......... .......... .....A.... T..C...T.A ..T...G... ..G.......
CBS 244.35   .....G.G.. .........CG .......G.. TG........ ...A.C...C ..GC......
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                     550        560        570        580        590        600
CBS 545.75    CAGTACCA-T TCAAACATCT CC--CTCAAT CTATTTTTTT TT----ATAG AGAATGAGAT
Cu-34         .......... .......... .......... .CT....... ..TAAA.A.. ..........
CBS 156.28    .......... .......... .......... .CT....... .A..AA.A.. ..........
CBS 595.68    .......... .......... .......... .....A.... ......T... ..........
Cu-230        .......... .......... .......... .CTA...... .A....-... ..........
CBS 160.28    .........C .AGT.A.... .-...C-CT- .C.CC..GG. GGT...--TT .A..G----G
Cu-95         .........C .AGT.A.... .-...C-CT- .C.CCC.GGG GGG...--TT .A..G----G
Cu-2          .........C .AGT.A.... .-...C-CT- .C.CC..GG. GGT...--TT .A.------G
MUCL 16087    .........C .AGT.A.... .-...C-CT- .C.CC..GG. GGT...--TT .A..-----G
NRRL 1380     .........C .A.T.A.... .-..TCTCT- A.CCC..GA. GAT...--.. .A..A----A
CBS 693.68    .........C .A.T.A.... .-..TCTCT- A.CC-..GA. GAT...--.. .A..A----A
Cu-137        .........C CA.T.A.... .T...CTCT- .C.CC...G. GGG...--T. G.TT.TT.G.
CBS 692.68    .........C .A.T.A.... .-...CTCTA .C.CC..GG. GAT...--TA G...A-----
CBS 133.27    .........C .A.T.A.... .......CTC .ATC...G.. GATG..-ATA G..TAA.A.A
Cu-15         ........AC ...T.A.... GT...AA.T- -..A..A... .ATT..-AT. .TT..ATTT.
NRRL 1375     .........C .A.T.A.... .-..-CTCT- .C.CC..GG. GGT...--TT .A..G-----
IFO 6736      ........AC .A.T.A.... .T....-..C .ATC...... GAT...--G. .ATT.T..TC
IMI 200623    ........AC .GTT..C..C .TTC...CCC A.TCG...GG G.TGAATGGT -.G.A.GA.G
CBS 347.69    ........AC .GT----..C .TTC...CCC A.TCG...GG G.TGAATGGT ..G.A.GA.G
NRRL 3009     ....G...T. .AC.TAT.TC .-.C..ACC. ...A.GG.GG GATCA.---- -...ATTA..
CBS 244.35    .....T...- -A.....C.C .A...A-TTC .A.ACC..GC G.T...--T. .A.TG..CT.

                     610        620        630        640        650        660
CBS 545.75    CA-GAGATAA ATTATAAAT- GGTCCTGGGT AAGCTGTGCT ATAGTCTTT- ---ATTGACT
Cu-34         .......... .......... .......... .......... .......... ..........
CBS 156.28    .......... .........A .......... .......... .......... ..........
CBS 595.68    .......... .......... .......... .......... .........T ATT.......
Cu-230        .......... .......... .......... .......... .......... ..........
CBS 160.28    A.G....... .....T.C.. ...T....TG .TT..TGAT. TATT-----. ...-------
Cu-95         G.G....... .....T.C.. ...T....TG .TT..TGAT. TATT.----. ...-------
Cu-2          G.A....... .....T.C.. ...T....TG .TT..TGATA TATA.----. ...-------
MUCL 16087    G.A....... .....T.C.. ...T....TG .TT..TGAT. TATT-----. ...-------
NRRL 1380     A.A....... .....T.C.. ........TG .TT..T.CTC T.TTG----. ...-------
CBS 693.68    A......... .....T.C.. ........TG .TT..T.TT. T.TT.T.A.. ...-------
Cu-137        TTC....... ..G..T.C.. ...T....TG .TTTCTGAT. ..TTA---.. ...-------
CBS 692.68    -.A....... ..G..T.C.. ...T....TG .TTT.TG.A. ..TT----.. ...-------
CBS 133.27    A.G....... ..C..T.C.. ...T....TG .TTT..GAT. T.TT.T.A.T ...-------
Cu-15         G.T....A.. ..GT.T.C.. ...T....TG GTCTCTCT.. T.T.-----. ...-------
NRRL 1375     A.C....... ..G..T.C.. ...-....TG .TTT.A.TT. ...T-----. ...-------
IFO 6736      A.GACATA.. T-...T.C.. ...T....TG .TT.AAAAT. TATT-----. ...-------
IMI 200623    G.TC...G.T ..AT.G.C.. ........TG GTAG.AG.G. T.GC.GCC.T GTCG.CCTGC
CBS 347.69    G.TCG..G.T ..AT.G.C.. ........TG GTAG.AG.G. T.GC.GCC.T GTCG.CCTGC
NRRL 3009     T.TA.A.A.G T.ATAT..A. AC.AGGTTT. T.A.CAA.T. T.GAA...CT GGCC.G.TGA
CBS 244.35    G.GA..T.CC .-CC.TGG.. ..AT----T- --T.----T. TA.A-----. ...-------

                     670        680        690        700        710        720
CBS 545.75    ATACCTGACG GAATTCTATC ACTACCCGCC CTTATATCTT TATATGGTAT AAGCTCGGTG
Cu-34         .......... .G........ .......... .......... ...--..... ..........
CBS 156.28    .......... .......... .......... .......... ...--..... ..........
CBS 595.68    .......... -......... .......... .......... ...--..... ..........
Cu-230        .......... .......... .......... .......... ...--..... ........-.
CBS 160.28    ---------- ---------- ---------- ---------- ---------- ----------
Cu-95         ---------- ---------- ---------- ---------- ---------- ----------
Cu-2          ---------- ---------- ---------- ---------- ---------- ----------
MUCL 16087    ---------- ---------- ---------- ---------- ---------- ----------
NRRL 1380     ---------- ---------- ---------- ---------- ---------- ----------
CBS 693.68    ---------- ---------- ---------- ---------- ---------- ----------
Cu-137        ---------- ---------- ---------- ---------- ---------- ----------
CBS 692.68    ---------- ---------- ---------- ---------- ---------- ----------
CBS 133.27    ---------- ---------- ---------- ---------- ---------- ----------
Cu-15         ---------- ---------- ---------- ---------- ---------- ----------
NRRL 1375     ---------- ---------- ---------- ---------- ---------- ----------
IFO 6736      ---------- ---------- ---------- ---------- ---------- ----------
IMI 200623    GGGGTGATGC AGTA.T---- ---------- ---------- ---------- ----------
CBS 347.69    GGGGTGATGC AGTA.T---- ---------- ---------- ---------- ----------
NRRL 3009     GCGGT.TTA. AGGAG----- ---------- ---------- ---------- ----------
CBS 244.35    ---------- ---------- ---------- ---------- ---------- ----------
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                     730        740        750        760        770        780
CBS 545.75    CTAGGAGGTA GGAGCATAGT AAAGAACCTA ACTTGCC-TT TGTCAGCCTT CTTCATCGAA
Cu-34         .......... .......... .......... .......... .......... ...T..T...
CBS 156.28    T......... .......... .......... .......C.. .......... ...T..T...
CBS 595.68    .......... .......... .T..--.... -......... .......... ...T..T...
Cu-230        .......... .......... .......... .......... .......... ......T...
CBS 160.28    ---------- ---------- ---------- -------.-- ---------- ----------
Cu-95         ---------- ---------- ---------- -------.-- ---------- ----------
Cu-2          ---------- ---------- ---------- -------.-- ---------- ----------
MUCL 16087    ---------- ---------- ---------- -------.-- ---------- ----------
NRRL 1380     ---------- ---------- ---------- -------.-- ---------- ----------
CBS 693.68    ---------- ---------- ---------- -------.-- ---------- ----------
Cu-137        ---------- ---------- ---------- -------.-- ---------- ----------
CBS 692.68    ---------- ---------- ---------- -------.-- ---------- ----------
CBS 133.27    ---------- ---------- ---------- -------.A- ---------- ----------
Cu-15         ---------- ---------- ---------- -------.-- ---------- ----------
NRRL 1375     ---------- ---------- ---------- -------.-- ---------- ----------
IFO 6736      ---------- ---------- ---------- -------.-- ---------- ----------
IMI 200623    -------... TCT.A.G.CA ...TCCA..C T.GAC.TAA. .A.A.AG.-- ----------
CBS 347.69    -------... TCT.A.G.CA ...TCCA..C T.GAC.TAA. .A.A.AG.-- ----------
NRRL 3009     -------.C. TCCT.TCCCG .--TCC.T.. TAGCTTTGGG ...TCA..G- ----------
CBS 244.35    ---------- ---------- ---------- -------.-- ---------- ----------

                     790        800        810        820        830        840
CBS 545.75    GGACATGATG CGACTGTGGG ACGCCCGATT ACCCTCGA-C TTAAATATCT GTT-AAGGTT
Cu-34         .......... .......... .......... .......... .......... ..........
CBS 156.28    .......... .......... .......... ..T....... .......... ..........
CBS 595.68    ...A...... .......... .......... .......... .......... ..........
Cu-230        .......... .......... .......... .......... .......... ..........
CBS 160.28    ---------- ---------A .GAA----.. ..T....... C.......-- ---.....C.
Cu-95         ---------- ---------A .GAA----.. ..T....... C.......-- ---.....C.
Cu-2          ---------- ---------A .GAA----.. ..T....... C.......-- ---.....C.
MUCL 16087    ---------- ---------A .GAA----.. ..T....... C.......-- ---.....C.
NRRL 1380     ---------- ---------A .AAA---..C ..T....GG. C.......-- ---.....C.
CBS 693.68    ---------- ---------A .AAAGGA.CC ..T....-.. C......C-- ---.....C.
Cu-137        ---------- ---------A .TCGAAA..G ..T...A-.. C.......-- ---.....C.
CBS 692.68    ---------- ---------C .T----A... G.T...A... C.......-- ---.....C.
CBS 133.27    ---------- ------AAAA .TCAAGA... G.T...A... C.......-- ---.....C.
Cu-15         ---------- ---------- -------.C. ..T...A... C.......-- ---.T...C.
NRRL 1375     ---------- -------AAA .-------.. ..T...A... C.......-- ---.T...C.
IFO 6736      ---------- ---------- ---------. TGAA.T.C.T C.C..CC.-- ---...ATA.
IMI 200623    --------C. GCTTAACC.A G..AAAAGGG -.....CGC. ..TT..C.TC CC.CT...GG
CBS 347.69    --------C. GCTTAACC.A G..AAAAGGG G.....CGC. ..TT..C.TC CC.CT...GG
NRRL 3009     --------C. GCTTAAACCA ....AAA.-- -.TT.A.GG. .G.TTGCGAC .G.CTT..--
CBS 244.35    ---------- ---------- ---------. ..AT.A.G.. C.G..CT.-- ---.TG.T..

                     850        860        870        880        890        900
CBS 545.75    AAATTCTTGA CTAATC---- ---TTTTGCA AAA-----AA GAAT--AGGA TAGAACTGGC
Cu-34         .......... ......C... .......... .......... ....T..T.. .....T....
CBS 156.28    .......... ......CT.T TTT.....A. ...GA..... ....T..... .....T....
CBS 595.68    .......... T.....CT.T TTT....... ...AAAAA.. ....T..T.. .....T....
Cu-230        .......... ......C... .......... .......... ....T..T.. .....T....
CBS 160.28    C--GA...TT T..T.A...G ATC.CGCATC TGGTAAAA-C CT.GT.C..C .TT..TA..A
Cu-95         C--GA...TT T..T.A...G ATC.CGCATC TGGTAAAA-C CT.GT.C..C .TT..TA..A
Cu-2          C--GA...TT T..T.A...G ATC.CGCATC TGGTAAAA-C CT.GT.C..C .TT..TA..A
MUCL 16087    C--GA...TT T..T.A...G ATC..GCATC TGGTAAAA-C CT.GT.C..C .TT..TA..A
NRRL 1380     C--GA...TT T.TTA.CA.G ATC..GCATC T.GTAAAA-C CT.GT.C..C .TT..TA.AT
CBS 693.68    C--GA...TT T.TTA.CAAG ATC..GCATC T.GTAAAA.C CT.GT.C..C .TT..TA.AT
Cu-137        C--GA...TT AA..AAAAGG TTT.CCCAGT TTTGTTTT-G TT.GT.C..C .TT..TA.AA
CBS 692.68    C--GA...T- ---.AAAGTT TTC....AG. .G.GTTTT-C AT.GT.C.-C .TT..TA.AA
CBS 133.27    .--GA....- ----AAA..G ATT.A..CTT T--.....-C TTGGT.C..C .TT..TA.AA
Cu-15         CT-GA...TT ------.GGG TTT.C.CT.. .--.....-- A.G.T....C .TT..TA.AA
NRRL 1375     C--GA...TT ..TT.T...T TTCCC.C.G. ...AAAAA.C C.G.C....C .TT..TA.AA
IFO 6736      ..-GG.A... ..T..T...C ATA...AA.C T.GTAAATTT ....T.CTAG .C.GCT.TAA
IMI 200623    C.--.GG..G AG..AGAGGG GAACC.GAG- T.GTAGGG.G .TT.TGCTTT G.T.GA.T.A
CBS 347.69    C.--.GG..G AG..AGAGGG GAACC.GAG- T.GTAGGG.G .TT.TGC--T G.T.GA.T.A
NRRL 3009     ----.T..AT TA..ATCTTG ACAG...A-- -..TATC..G CTT.A.---- -----A..AA
CBS 244.35    TT---....C ..TGAA...C ATT....--- T..TATAA.G ....G.C--- .CT.GTAAAA
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                     910        920        930        940        950        960
CBS 545.75    TTTAATGTTT TTACATCTAG AGTTATAAAT -CATTTTGAC TCCTGATGGG -AAAAAAAGC
Cu-34         .......... .......... .......... .......... .......... ........AA
CBS 156.28    .A........ .......... .......... T......... .........- ........AA
CBS 595.68    .......... .......... .......... .......... .........A A.......AA
Cu-230        .......... .......... .......... .......... .......... ..........
CBS 160.28    ...-..-..C ...TT---.. G.....--.- .------AC. AT.--..--- .---------
Cu-95         ...-..-..C ...TT---.. G....---.- .------AC. AT.--..--- .---------
Cu-2          ...-..-..C ...TT---.. G.....--.- .------AC. AT.--..--- .---------
MUCL 16087    ...-..-..C ...TT---.. GT....--.- .------.C. AT.--..--- .---------
NRRL 1380     ...T..-... C..TT---.A GT....--.- .------.C. ATT--C.--- .---------
CBS 693.68    ...T..-... C..TT---.A GT....--.- .------... ATT--C.--- .---------
Cu-137        ...-..-.C. A..A----GA GT....--.- .------.C. ..TAAC.--- .---------
CBS 692.68    ...-..-.C. A..A----.. G.....--.- .------.C. ----AC.--- .---------
CBS 133.27    ...-..-.C. A..A.---.. GT....--.- .------.C. ATT--TA--- .---------
Cu-15         ...C..-... ..T.TA-..A G.....TTT- .------.C. A----.A--- .---------
NRRL 1375     ...C..-... ..T.TA...A G.....--T- .------.C. A--------- .---------
IFO 6736      .AG.T.-.A. ..CT.ATA.. GT.A..TTT- .------.C. ATACTT.--- .---------
IMI 200623    G..TT.T... ..CTG.AA.. TT...C--T. TGCAGGATC. AATG.G.--- .--C------
CBS 347.69    G..TT.T... ..CTG.AA.. TT...C--T. TGCAGGATC. AATG.G.--- .--C------
NRRL 3009     GG.C.CC.C. C.CACCAG.. G..C.---T. CAT.GGA.T. A..C.CC--- .--C------
CBS 244.35    CAG.C.-..C ..-------- G.GG------ .------.C. ...CA.A--- .---------

                     970        980        990       1000       1010       1020
CBS 545.75    TCAAGAGTTC TTTACCGAAT TCTTTTGCCC ACTTTTCCTT TTTTTTGGCC TGAAATCAGA
Cu-34         GT....--A. ...--..GG. .....CT..- .T......A. .......... ..........
CBS 156.28    GT....--A. ...--..GG. .....----- ....---.G. .......... ..........
CBS 595.68    AA..A..AA. ...--..GG. .....CTAT- .T......A. .......... ..........
Cu-230        .......... ....-..... .......... ........A. .......... ..........
CBS 160.28    --------.- -...-----C CT..------ --------AA A.C-...... ..T.......
Cu-95         --------.- -...-----C CT..------ --------AA A.C-...... .....C....
Cu-2          --------.- -...-----C .T..------ --------AA A.CA...... ..........
MUCL 16087    --------.- -...-----C .T..------ --------AA A.C-...... ..........
NRRL 1380     --------.- -A..-----. .T...----- -----A--AA A.C....... ..........
CBS 693.68    --------.- -A..-----. .T...----- -----A--AA A.C..-.... ..........
Cu-137        --------.- -...-----A ..C------- --------AA AAA....... ..........
CBS 692.68    --------.- -...-----A .....----- -----.TTAA AAAC...A.. ...T......
CBS 133.27    --------.- -...-----. .T...----- -----.TAAA A.C-...... ..........
Cu-15         --------A- -A.T-----. .T..------ --------AA A..-...... ..........
NRRL 1375     --------.- -CAC-----. .T..A----- -----A-.AA AAC-...... ..........
IFO 6736      --------.- -AAT-----. .AA..----- -----.--AA A..-...... ..........
IMI 200623    ---------- -......C-C .A...----- GGAAC..TA. CC........ ..........
CBS 347.69    ---------- -......C-C .A..------ GGAAC..TA. CC........ ..........
NRRL 3009     ---------- -.A.TTT--- .A..------ CAAAAA.TA. AA........ ..........
CBS 244.35    --------.- -AA.-----. CA..C----- -----.--.A AAC-...AT. .........C

                    1030       1040       1050       1060
CBS 545.75    TG-GGACTAC CCGCTGAACT TAAGCATATC AATAAGCGGA GGA
Cu-34         .......... .......... .......... .......... ...
CBS 156.28    .......... .......... .......... .......... ...
CBS 595.68    .......... .......... .......... .......... ...
Cu-230        .......... .......... .......... .......... ...
CBS 160.28    --..CC.... .......... .......... .......... ...
Cu-95         ..G.AC.... ..A....... .......... .......... ...
Cu-2          ....CC.C.. .......... .......... .......... ...
MUCL 16087    .......... .......... .......... .......... ...
NRRL 1380     .......... ..C....... .......... .......... ...
CBS 693.68    .......... ..C....... .......... .......... ...
Cu-137        .....C.... .......... .......... .......... ...
CBS 692.68    .......... ..C....... .......... .......... ...
CBS 133.27    .......... ..C....... .......... .......... ...
Cu-15         .......... .......... .......... .......... ...
NRRL 1375     .......... .......... .......... .......... ...
IFO 6736      .......... .......... .......... .......... ...
IMI 200623    .......... .......... .......... .......... ...
CBS 347.69    .......... .......... .......... .......... ...
NRRL 3009     .......... .......... .......... .......... ...
CBS 244.35    G.....T... .......... .......... .......... ...
```

Fig. 1. Alignment of ITS sequences of *Cunninghamella* spp. using CBS 244.35 of *Mucor hiemalis* f. *luteus* as an outgroup. The complete alignment was generated by CLUSTAL_X (1.64b) with multiple alignment mode. Sites 1-30 represent 18S rDNA; ITS1 region from site 31 to 393; 5.8S coding region from site 394 to 551; ITS2 region from site 552 to 1002; and 5' end of 25S coding region from site 1003 to 1063. Nucleotides matched with CBS 545.75 are indicated by dots.

Systematic analyses

Pairwise genetic distances of the 20 strains examined were calculated by the program DNADIST in the package PHYLIP (3.5c) using the Kimura two-parameter model (Kimura, 1980) (Table 3). From these data, different values for the three taxonomic ranks — strain, variety and species can be found. Genetic distances among the 4 strains of *C. elegans* (Cu-2, CBS 160.28, Cu-95 and MUCL 16087), between the 2 strains of *C. bertholletiae* (NRRL 1380 and CBS 693.68) and between the 2 strains of *C. intermedia* (IMI 200623 and CBS 347.69) are less than 0.020. Genetic distances among the 4 varieties of *C. echinulata,* i.e. var. *echinulata* (CBS 156.28), var. *antarctica* (CBS 545.75), var. *nodosa* (Cu-34) and var. *verticillata* (CBS 595.68), are 0.024-0.059; while those among different species, except *C. septata,* are more than 0.102. *C. septata,* though it is entirely distinct from the others in morphology and did not form zygospores with any of them (Zheng & Chen, 2001), has genetic distances of 0.014-0.051 among itself and the 4 varieties of *C. echinulata.* Genetic distances provide a scale for the delimitation of species, however, they seem to be unsuitable for the separation of genera, as the values among some species of *Cunninghamella* are higher than those between the strain *Mucor hiemalis* f. *luteus* (CBS 244.35) and each of the strains of *Cunninghamella.*

A neighbor-joining bootstrap phenogram (Fig. 2) was constructed with TREECON for Windows (Van de Peer & De Wachter, 1994) to illustrate systematic relationships among species based on the sequence data shown in Fig. 1, using the Kimura evolutionary model with 1000 replications. Bootstrap values are higher than 50% for all internal nodes. The majority of the branches were supported at a high level of confidence. The 4 strains of *C. elegans*, CBS 160.28 (T) , Cu-2, Cu-95 and MUCL 16087, formed a clade with 100% confidence, indicating that the two Chinese strains and the Belgian strain, received as *C. blakesleeana,* of this species, were identified or re-identified correctly. Two pairs of strains, NRRL 1380 (NT) and CBS 693.68 (NT of *C. poly-*

Table 2. Length (bp) of ITS1, 5.8S and ITS2 regions of ribosomal RNA gene in different strains based on the sequence data shown in Fig. 1 (See Table 1 for names of strains).

	CBS 545.75	Cu-34	CBS 156.28	CBS 595.68	Cu-230	CBS 160.28	Cu-95	Cu-2	MUCL 16087	NRRL 1380	CBS 693.68	Cu-137	CBS 692.68	CBS 133.27	Cu-15	NRRL 1375	IFO 6736	IMI 200623	CBS 347.69	NRRL 3009	CBS 244.35
ITS1	236	235	228	237	273	257	257	257	256	318	304	291	282	283	328	281	241	285	264	302	218
5.8S	154	153	154	155	154	154	154	154	154	154	155	155	155	155	154	154	155	155	155	156	153
ITS2	420	419	419	428	417	204	204	203	203	213	218	218	204	220	199	205	215	343	338	311	183
Total	810	807	801	820	844	615	615	614	613	685	677	664	641	658	681	640	611	783	757	769	554

Table 3. Genetic distances between pairs of fungal strains calculated by the program DNADIST in the package PHYLIP (3.5c) using the Kimura two-parameter model from the complete sequence data shown in Fig.1 (See Table 1 for names of strains).

	CBS 545.75	Cu-34	CBS 156.28	CBS 595.68	Cu-230	CBS 160.28	Cu-95	Cu-2	MUCL 16087	NRRL 1380	CBS 693.68	Cu-137	CBS 692.68	CBS 133.27	Cu-15	NRRL 1375	IFO 6736	IMI 200623	CBS 347.69	NRRL 3009
CBS 545.75																				
Cu-34	0.0252																			
CBS 156.28	0.0414	0.0244																		
CBS 595.68	0.0556	0.0386	0.0587																	
Cu-230	0.0136	0.0171	0.0352	0.0507																
CBS 160.28	0.3769	0.3679	0.3788	0.3884	0.3911															
Cu-95	0.3857	0.3799	0.3877	0.3945	0.3998	0.0130														
Cu-2	0.3748	0.3658	0.3766	0.3861	0.3889	0.0115	0.0188													
MUCL16087	0.3617	0.3528	0.3633	0.3730	0.3759	0.0145	0.0203	0.0144												
NRRL 1380	0.3827	0.3746	0.3844	0.4062	0.4226	0.1187	0.1270	0.1220	0.1030											
CBS 693.68	0.3786	0.3706	0.3811	0.4019	0.4100	0.1157	0.1239	0.1206	0.1018	0.0134										
Cu-137	0.4274	0.4247	0.4307	0.4460	0.4638	0.1820	0.1889	0.1816	0.1722	0.2109	0.2106									
CBS 692.68	0.3811	0.3750	0.3798	0.3896	0.4188	0.1575	0.1648	0.1557	0.1461	0.1840	0.1831	0.1257								
CBS 133.27	0.3883	0.3813	0.3853	0.4053	0.4039	0.1734	0.1823	0.1731	0.1633	0.1788	0.1686	0.1890	0.1372							
Cu-15	0.3903	0.3818	0.3744	0.4124	0.4168	0.2760	0.2847	0.2688	0.2595	0.3393	0.3153	0.3077	0.2908	0.2896						
NRRL 1375	0.3829	0.3723	0.3779	0.3777	0.3945	0.1710	0.1822	0.1768	0.1667	0.2056	0.2027	0.2195	0.1762	0.2027	0.2380					
IFO 6736	0.6089	0.5773	0.6093	0.6144	0.5714	0.4298	0.4420	0.4319	0.4119	0.4573	0.4522	0.5164	0.4843	0.4216	0.5377	0.4877				
IMI 200623	0.6188	0.6049	0.6439	0.6324	0.6717	0.4699	0.4699	0.4693	0.4461	0.5422	0.5466	0.5431	0.5277	0.4969	0.6092	0.5393	0.6882			
CBS 347.69	0.6291	0.6191	0.6516	0.6469	0.6476	0.4723	0.4722	0.4687	0.4483	0.5274	0.5331	0.5373	0.5180	0.4969	0.5981	0.5378	0.6916	0.0109		
NRRL 3009	0.7389	0.7328	0.7278	0.7598	0.7929	0.6218	0.6274	0.6163	0.5951	0.6288	0.6266	0.6683	0.5974	0.6160	0.6685	0.6113	0.7824	0.5821	0.5682	
CBS 244.35	0.6172	0.6182	0.6431	0.6428	0.6284	0.4957	0.4964	0.4979	0.4873	0.5277	0.5211	0.5720	0.5098	0.4970	0.5596	0.4992	0.5147	0.7083	0.7254	0.7316

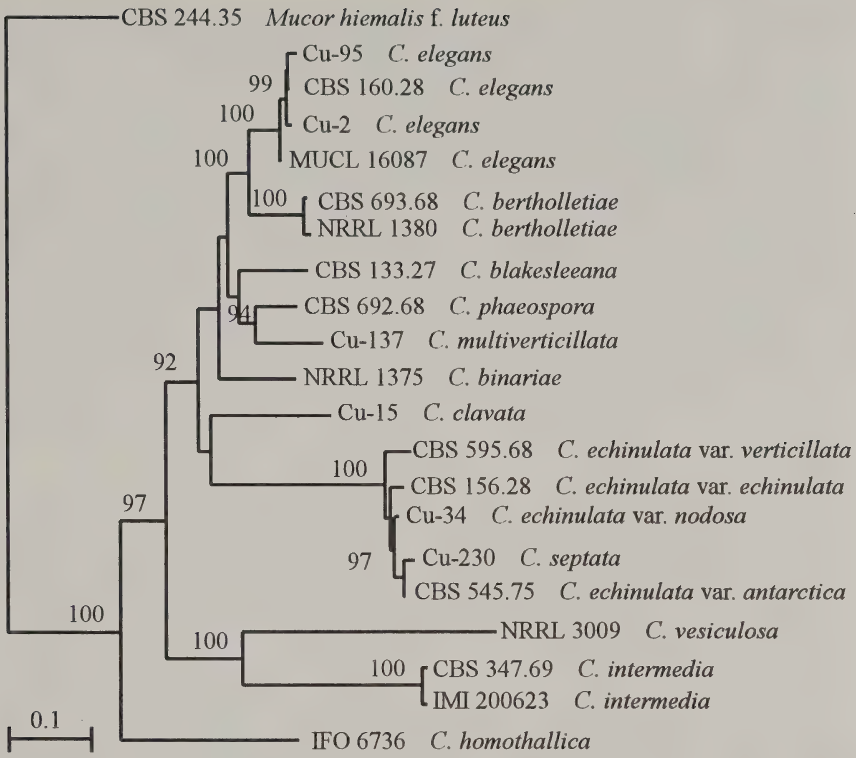
CBS 244.35 *Mucor hiemalis* f. *luteus*
Cu-95 *C. elegans*
CBS 160.28 *C. elegans*
Cu-2 *C. elegans*
MUCL 16087 *C. elegans*
CBS 693.68 *C. bertholletiae*
NRRL 1380 *C. bertholletiae*
CBS 133.27 *C. blakesleeana*
CBS 692.68 *C. phaeospora*
Cu-137 *C. multiverticillata*
NRRL 1375 *C. binariae*
Cu-15 *C. clavata*
CBS 595.68 *C. echinulata* var. *verticillata*
CBS 156.28 *C. echinulata* var. *echinulata*
Cu-34 *C. echinulata* var. *nodosa*
Cu-230 *C. septata*
CBS 545.75 *C. echinulata* var. *antarctica*
NRRL 3009 *C. vesiculosa*
CBS 347.69 *C. intermedia*
IMI 200623 *C. intermedia*
IFO 6736 *C. homothallica*
99
100
100
100
94
92
100
97
97
100
100
100
0.1

Fig. 2. Neighbor-joining bootstrap phenogram illustrating relationships among *Cunninghamella* species based on sequence data shown in Fig.1. CBS 244.35 *Mucor hiemalis* f. *luteus* was used as an outgroup to root the tree. The percentages given at the internal nodes represent the confidence limits of the branches in bootstrap analyses using 1000 replicates. Branch lengths (drawn in the horizontal dimension only) are proportion to the number of nucleotide changes. The bar at the lower left indicates the distance corresponding to one base per 10 nucleotides.

morpha) of *C. bertholletiae*, and IMI 200623 (T) and CBS 347.69 (T of *C. brunnea*) of *C. intermedia*, formed separate clades with 100% confidence. These results support the synonymy of *C. polymorpha* with *C. bertholletiae* by Weitzman & Crist (1979, 1980) and Zheng & Chen (2001), and the synonymy of *C. brunnea* with *C. intermedia* by Zheng & Chen (2001). The 4 varieties of *C. echinulata* also clustered in a clade with 100% confidence with each variety supported by a longer branch. This result supports the view that *C. antarctica*, *C. echinulata* var. *nodosa* and *C. verticillata* (= *C. blakesleeana* var. *verticillata*) are conspecific with C. *echinulata* but they should be retained as the following distinct varieties: *C. echinulata* var. *echinulata*, var. *antarctica*, var. *nodosa,* and var. *verticillata* (Zheng & Chen, 2001). Although *C. septata* clustered with these 4 varieties in the same clade, and *C. phaeospora* and *C. multiverticillata* formed a clade, they are resolved as systematically distinct species. Except for *C. septata* and *C. multiverticillata*, all species were clustered in different clades. Among which, *C. binariae* and *C. clavata* are recently described new species. The type of *C. binariae* NRRL 1375 was received as *C. bertholletiae*, but these taxa are only distinctly related. While *C. bertholletiae, C. blakesleeana, C. phaeospora, C. intermedia* have been treated as synonyms of other species (see Table 1 of Zheng & Chen, 2001 for the details), results of the molecular systematics indicates that all of these species are systematically distinct. The only two species accepted by all authors, *C. vesiculosa* and *C. homothallica*, are resolved as distinct species in the present study.

In general, the rDNA ITS region is highly variable even among closely related taxa, but putative sibling species may show little difference in their ITS sequences. The ITS1 region has been reported to contain more nucleotide variants than the ITS2 in genera such as: *Alternaria* (Jasalavich *et al.*, 1995), *Leptosphaeria* (Morales *et al.*, 1995) and *Phytophthora* (Cooke & Duncan, 1997) etc. On the other hand, O'Donnell *et al.* (1998) reported more variation in the ITS2 than in the ITS1 and designed two ITS2-specific PCR primers for separating *Fusarium* species into two ITS2 sequence types. Ko *et al.* (1997) observed that distances among the strains of *Trichaptum* are less than 0.025 in ITS1 and less than 0.040 in ITS2. Similarly in our study, distances among strains of the same species of *Cunninghamella* range from 0.0039 to 0.0288 in the ITS1 and from 0.0090 to 0.0358 in the ITS2. These results demonstrate that in some genera, the ITS1 is more variable than ITS2, but in others the converse is true. In either case, the variations, no matter high or low, are very useful for identification and classification. Species concepts based solely on a single gene have been considered insufficient to be representative of all characters (Seifert *et al.*, 1995). However, the ITS region is used extensively to discriminate and help define new species such as in *Ascosphaera* (Anderson *et al.*, 1998), and the edible shiitake mushroom *Lentinula* (Hibbett *et al.*, 1995) as well as the phytopathogenic fungus *Colletotrichum* (Sherriff *et al.*, 1994). Results of our study suggest that this region is useful for species level systematics within *Cunninghamella.*

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A NEW NEOJOHNSTONIA SPECIES FROM BRAZIL

LUÍS FERNANDO PASCHOLATI GUSMÃO*
Departamento de Ciências Biológicas, Universidade Estadual de Feira de Santana, Caixa
Postal 252, 44031-460, Feira da Santana, BA, Brazil
(lgusmao@mail.uefs.br)

ROSELY ANA PICCOLO GRANDI
Seção de Micologia e Liquenologia Instituto de Botânica, Caixa Postal 4005,
01061-970, São Paulo, SP, Brazil

ABSTRACT

Neojohnstonia minima, a new species of dematiaceous Hyphomycetes, is described and illustrated. It is characterized by branched conidiophores, delicate denticles on conidiogenous cells and verruculose, ellipsoid conidia.

Keywords: *Johnstonia*, Mitosporic fungi.

INTRODUCTION

In the course of investigations of the microfungi associated with leaf litter of native plants of State of Bahia, Brazil, an interesting fungus was found which turned out to be an apparently undescribed species of *Neojohnstonia* (M. B. Ellis) B. Sutton.

The genus *Johnstonia* was erected by Ellis (1971), with a single species *J. colocasiae*, collected in Indonesia on living leaves of *Colocasia* spp., including *C. esculenta*, causing round or irregular yellow to brown leaf spots. Later it was collected in other localities on the same hosts, viz. India (Roy et al., 1982), Papua-New Guinea, Western Samoa, Malaysia (Ellis, 1971) and in Cuba on decaying leaves of *Miconia laevigata* (Castañeda Ruiz & Kendrick, 1990).

Sutton (1983) proposed the new name *Neojohnstonia* for *Johnstonia* M. B. Ellis, because the latter name had been used earlier for a genus of Fossils plants from the Mesozoic (Walkom, 1925 according to Sutton, 1983).

Until now, *Neojohnstonia* has been a monotypic genus with *N. colocasiae* as the type species (Sutton, 1983). This genus is mainly characterized by having much branched conidiophores, the presence of the delicate denticles on monoblastic or occasionally polyblastic conidiogenous cells and ellisoid to subglobose, 1-septate, verruculose conidia.

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* Corresponding author

TAXONOMIC PART

Neojohnstonia minima Gusmão & Grandi, **anam. sp. nov.** (Fig. 1-5).
Etymology: Lat. *minima*, referring to the conidial size.

Fungi mitosporici, Hyphomycetes, Dematiaceae. Teleomorphosis ignota.
Coloniae effusae, arachnoideae vel pilosae, atro-brunneae vel fuscae; **conidiophorae** usque ad 130µm longae, 2-5µm crassae, multiramosae, pallide brunneae; **cellulae conidigenae** saepe monoblasticae, aliquando polyblasticae, fere in ramulis incorporatae, determinatae vel sympodiales, cum denticulis delicatis longis; **conidia** solitaria, ellipsoidea, 1-septata, verruculosa, pallide brunnea, 6-8 x 3.5-4.5µm.
Specimina examinata: In foliis putrecentibus (Lamiaceae), Serra do Orobó, Rui Barbosa, Bahia, Brazil, L. F. P. Gusmão, 31.07.2000, HUEFS42773 (Holotypus); L. F. P. Gusmão, 03.08.2000, HUEFS42774; L. F. P. Gusmão, 13.06.2000, HUEFS42731.

Mitosporic fungi, dematiaceous Hyphomycetes. Teleomorph unknow.
Colonies effuse, arachnoid or hairy, dark brown or blackish brown; **conidiophores** up to 130µm long, 2-5µm thick, much branched, pale brown; **conidiogenous cells** often monoblastic, occasionally polyblastic, integrated, determinate or sympodial, with long delicate denticles; **conidia** solitary, ellipsoidal, 1-septate, verruculose, pale brown, 6-8 x 3.5-4.5µm.
Specimens examined: On decaying leaves of Lamiaceae, Serra do Orobó, Rui Barbosa, Bahia, Brazil, L. F. P. Gusmão, 31 July 2000, HUEFS42773 (Holotype); L. F. P. Gusmão, 03 Aug 2000, HUEFS42774; L. F. P. Gusmão 13 June 2000, HUEFS42731. (permanent slides)
Other material examined: on decaying leaves of *Walteria cinerescens* A. St. Hill. (Sterculariaceae), Serra do Orobó, Rui Barbosa, Bahia, Brazil, L.F.P. Gusmão, 17 June 2000, HUEFS42732.

To justify the distinct identity of the new collections, a comparison with the type species is presented in Table 1. This species differs from *N. colocasiae* in having shorter ellipsoid conidia and longer delicate denticles. Therefore, the Brazilian specimens may be described as a new species of *Neojohnstonia*..

Table 1. Comparison of *N. minima* sp. nov. and *N. colocasiae*.

	Conidia		Conidiophores
Species	Size (µm)	Shape	Size (µm)
N. colocasiae	9-11(10.5) x 7.5-10(9)	Ellipsoid to subspheric	Up to 150 x 2-5
N. minima	6-8 x 3.5-4.5	Ellipsoid	Up to 130 x 2-5

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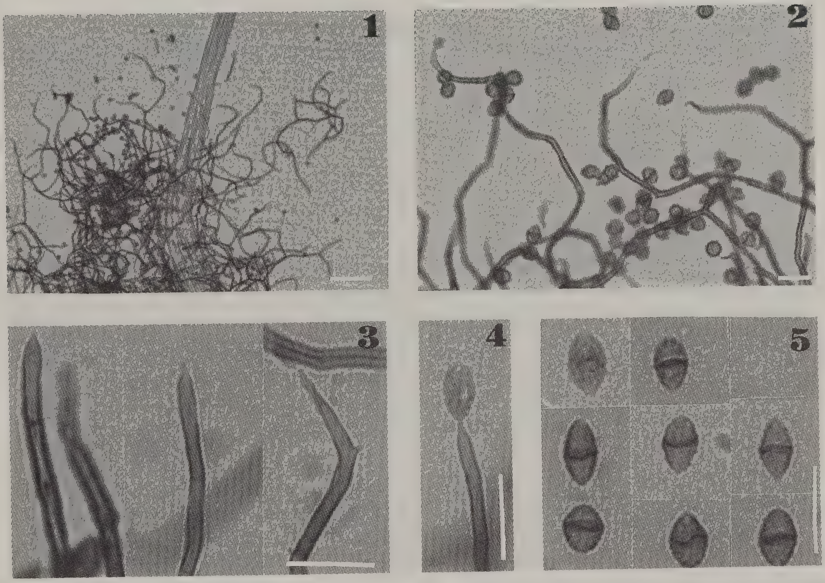

Figs 1-5. ***Neojohnstonia minima***. Fig.1. Colony growing on leaf trichome. Fig. 2. conidiophores and conídia. Fig. 3. Detail of conidiogenous cells and denticles. Fig. 4. Yong conidium attached with the conidiogenous cells. Fig. 5. Conidia. (Fig.1., bar = 50μm; other Figs., bar = 10μm).

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DIPLOOSPORA INDICA, A NEW SPECIES OF HYPHOMYCETES

SREEKALA, K. NAIR and D.J. BHAT *

Department of Botany, Goa University
Taleigao Plateau, Goa-403 206, INDIA
*djbhat@unigoa.ernet.in

ABSTRACT

A new species of Hyphomycetes, *Diploospora indica* Sreekala & Bhat, isolated from freshwater foam and submerged leaf litter of *Dipterocarpus laevis*, is described from India. The new taxon is compared with known species of the genus and other similar genera.

KEY WORDS: limnology, streams, taxonomy, India.

INTRODUCTION

During a taxonomic survey of aquatic fungi of the forests of Western Ghat mountain ranges in southern India, a number of elongate, aseptate, fusiform, smooth and dorsi-ventrally flat conidia were encountered in foam and on submerged leaf litter of *Dipterocarpus laevis* Buch. (Dipterocarpae) gathered from a freshwater stream in Cotigao Wildlife Sanctuary in the State of Goa. The fungus was brought to culture and is described here as a new species of the genus *Diploospora* Grove.

METERIALS AND METHODS

Fresh foam was gathered by gently shoveling a glass petri plate lid through a foam cake found accumulated along the edge of a fast flowing stream in Cotigao Wildlife Sanctuary, Goa. A few drops of the liquid foam were flooded over 2% malt extract agar (MEA) plates mixed with a cocktail of antibiotics (bacitracin 0.02 g, neomycin 0.02 g, penicillin G 0.02 g, polymixin 0.02 g, streptomycin 0.02 g and terramycin 0.04 g dissolved in 10ml of sterile distilled water and added to 1 L of cooling sterile MEA medium). The foam-flooded agar plates were rotated orbitally so as to have an uniform spread of the spores. The foam-spora plates were transported to the laboratory in an ice box maintained at 4°C.

The submerged leaf litter collected from the stream was thoroughly rinsed, initially in stream water and later with deionized tap water after transporting to the laboratory in fresh polythene bags. After incubation in sterile distilled water in a vertical glass jar and agitation at 20-22°C in a continuous flow of sterile air, conidia laden bubbles were observed on the surface after five days. They were transferred to MEA plates by gently scooping the surface water from the jar and spreading it over the agar surface. Single germinating conidia were detected under the dissecting microscope and aseptically isolated from both foam and leaves onto fresh MEA plates using a sterile flattened needle. The plates, sealed with parafilm in order to protect them from mites and other contaminants, were incubated in a day light growth chamber at 20-22°C. The fungus grew well reaching up to 10 mm diam in 10 days but sporulated sparsely on the agar surface even after three weeks of incubation.

DESCRIPTION

Diploospora indica Sreekala *et* Bhat **anam. sp. nov.** (Fig. 1)

Fungi conidiali, Hyphomycetes. Coloniae concentricae, effusae, albae, margine laeviae; reversione concoloriae vel pallide brunneae. Mycelium superficiale et immersum, ex hyphis ramosis, septatis, laevibus, incoloris, 1.5-2 µm crassis compositum. Conidiophora terminali vel laterali, mononematica, recta, flexuosa, laevia, 2-7-septata, ramosa, pallide brunnea, tenue crassitunicata, 75-125 x 3-5 µm. Cellulae conidiogenae integratae, polyblasticae, apicales, post secessionem conidiorum ad apicem, truncatae, 10-22 x 3-4 µm. Conidia in pseudocatenas acropetas longas, ad basim ramosas, fusoidea, utrinque truncata, laevia, aseptata, dorsi-ventrale leviter applanata, incolorata vel subhyalina, pallide brunnea in massa, 12-33 x 3-4 µm; ramoconidia aseptata, longa, basi truncata; cicatrices terminales, 2-5.

HOLOTYPE, dried culture mat derived from single spore isolate IMI 384550 (1); ex Herb. No. GUFCC-161 (Isotype); Cotigao Wild Life Sanctuary, South Goa, India, _Sreekala, K. Nair; 19.VII.1999.

Conidial fungus, Hyphomycete. Colonies consisting of concentrically zonate hyphae alternating with conidial mass, effuse, white, with smooth margin, slow growing, reaching 0.5-1.0 cm diam. in 10 days, reverse of the colony colourless to pale brown. Mycelium partly superficial, composed of smooth, colourless hyphae 1.5-2 µm wide. Conidiophores terminal or lateral, mononematous, erect, flexuous, smooth, moderately thick-walled, 2-7-septate, branched, pale brown in mass, 75-125 x 3-5 µm. Conidiogenous cells integrated, polyblastic, 10-22 x 3-4 µm, apically truncate after secession of conidia. Conidia in long, acropetal, simple to proximally branched, false chains, fusiform, narrow and truncate at both ends, dorsi-ventrally flat, smooth-walled, aseptate, hyaline to very slightly pigmented, pale brown in mass, 12-33 x 3-4 µm; ramoconidia aseptate, truncate at the base, with 2-5 terminal flat scars.

Hughes (1968) examined and redescribed *Diploospora rosea* Grove, the type species of the genus *Diploospora* Grove, from the type collection maintained in W.B. Grove's herbarium in Herb. BM. The genus *Diploospora* is characterised by its catenate, hyaline but in mass dull pink-coloured, 1-2-septate, conidia in acropetal,

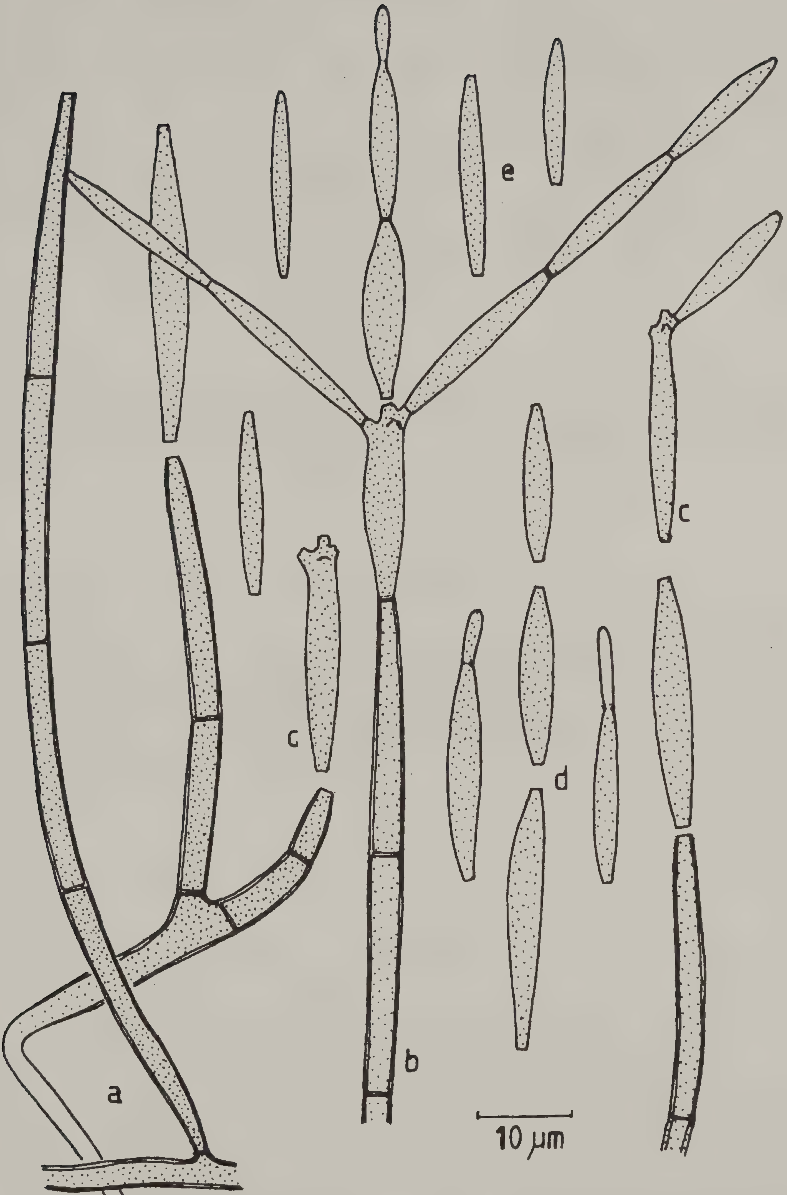

Fig.1. *Diploospora indica*. a. conidiophores, b. conidiophore with ramoconidia and conidia, c. ramoconidia, d. mature conidium showing acropetal development of conidia, e. conidia. (All drawn from pure culture).

branched chains developing on hyaline, simple, branched conidiophores. The conidia of *D. rosea* are cylindrical to broadly ellipsoidal and truncate at each slightly denticulate raised end (Hughes, 1968). The conidia of the second species known in the genus, *D. longispora* Matsushima (1975), are 1-3 septate and cylindrical. Those of *D. indica* are however aseptate and fusiform. *Diploospora rosea* and *D. longispora* are terrestrial whereas the conidia of *D. indica* were collected in an aquatic habitat although they may have been washed in from nearby litter.

The genus *Diploospora* shows some similarity with dematiaceous genera such as *Cladosporium* Link, Lylea Morgan-Jones, *Ramularia* Unger, *Septocylindrium* Bonord. ex Sacc. and *Septonema* Corda wherein the conidiophores are robust and stiff and the catenate conidia are moderately to dark-coloured and of varying shapes (Carmichael et al., 1980; Matsushima, 1975).

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A NEW SPECIES OF TRICHOBOTRYS FROM THE WESTERN GHAT FORESTS, INDIA

MARIA D'SOUZA and D. J. BHAT

Department of Botany, Goa University, Goa-403 206, India

ABSTRACT

A new dematiaceous hyphomycete, *Trichobotrys ramosa* sp. nov., isolated from decaying leaves of *Dendrocalamus strictus* Nees (F. Poaceae) is described and illustrated from the forests of Western Ghats in southern India.

INTRODUCTION

During our studies on the taxonomy and diversity of microfungi occurring in association with flowering plants of the Western Ghats in southern India, an interesting hyphomycete producing catenate, dark brown, spherical and echinulate conidia on fertile lateral branches with polyblastic conidiogenous cells developing on dichotomously branched, flexuous conidiophores was isolated from fallen and dead leaves of *Dendrocalamus strictus* Nees from Mollem forest in Goa State. The fungus is described here as a new species of the genus *Trichobotrys* Penzig & Saccardo.

The dead and decaying leaves of *Dendrocalamus strictus* were thoroughly washed in distilled water and incubated in sterile moist chamber for 7-14 days. Fungal colonies appeared on the leaf surface were individually examined under the microscope.

TAXONOMIC PART

Trichobotrys ramosa Maria et Bhat sp. nov. (Figure 1)

Coloniae effusae, atro brunneae, velutinae. *Mycelium* partim superficialis, partim immersis, hyphae ramosae, hyalinae vel pallide brunneae 1.5-2.5 μm lat. compositae. *Seta* absentia. *Conidiophora* mononematosa, erecta, recta vel flexousa, septata, ramosa dichotome in supra, fertilis in media, atro- vel rubrobrunnea, verruculosa, 330-600 μm longa, 10-18 μm lata ad basim, 8-10 μm lata et conspicuus echinulata ad inferne dimidiata, terminaliter in sterilis, setiformis, diverse curvata, pale brunnea vel hyalina, usque ad 6 μm lata ad apicalis; conidiophoris ramosis fero bravis, fertilis, atro vel pallide brunnis, verruculosis, laxe spatii, 1-2-septatis, usque ad 25 μm longis, 3-5 μm latis lateralis formatis. *Cellulae conidiogenae* in conidiophoris incorporatae, polyblasticae, subterminalis vel terminalis ad ramosis fertilis, denticulatae in supra dimidiatae, elongatae, interdum lapsum into cupulatum formata,5-10 x 2-3 μm. *Conidia* sicca, catenata, plerumque in ramosa, acropetalis catenula, globosa, atro brunnea, verruculosa, aseptata, 3-5 μm diam.

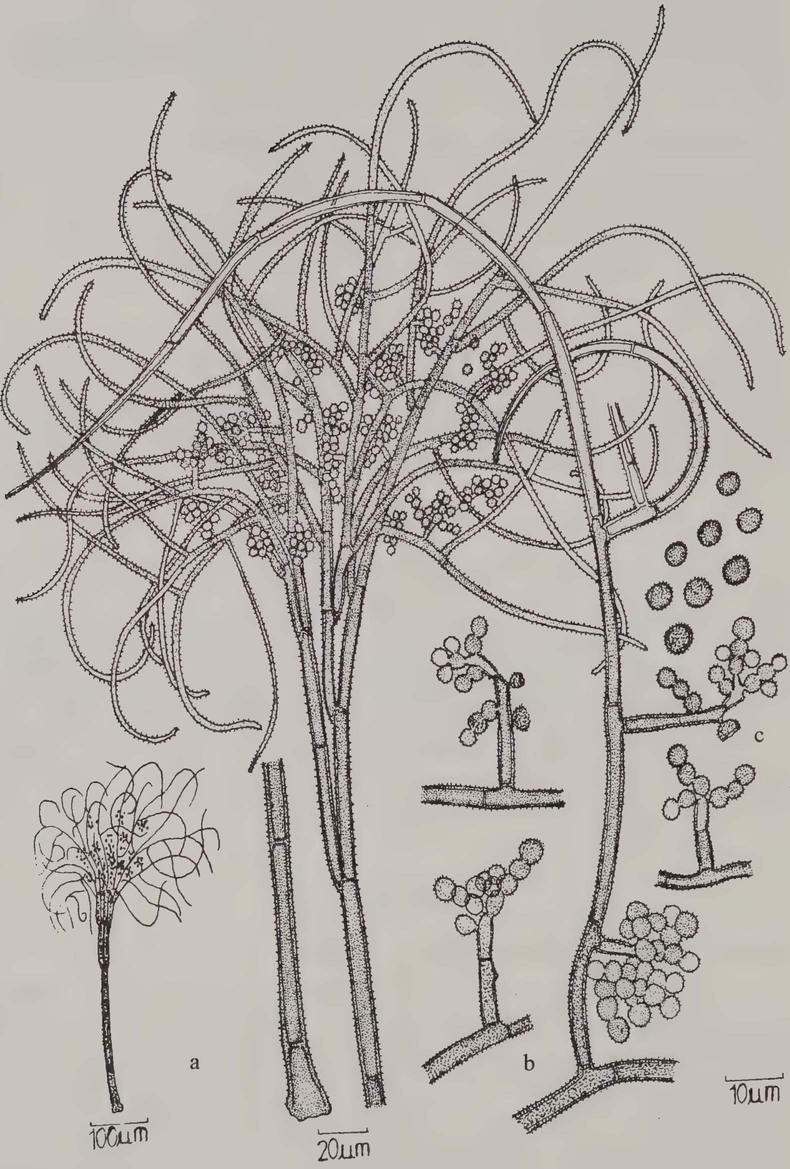
a
100µm
20µm
b
c
10µm

Fig. 1. *Trichobotrys ramosa*, a. Entire conidiomata; b. Portion of conidiophore with fertile lateral branches; c. Conidiogenous cell and conidia.

In foliis putrescentibus *Dendrocalamus strictus* Nees, Mollem, Bhagwan Mahavir Wildlife Sanctuary, Goa, India, 11 March 1999, M.D' Souza, Herb. No. IMI 386393 holotypus, GUFCC-0274, isotypus.

Terrestrial litter, hyphomycete. *Colonies* effuse, dark olivaceous brown, velvety. *Mycelium* partly superficial, partly immersed, composed of branched, colourless to pale brown hyphae 1.5-2.5 μm wide. *Setae* absent. *Conidiophores* mononematous, erect, straight or flexous, septate, dichotomously branched in the above half, fertile in the middle, dark to reddish brown, verruculose, 330-600 μm long, 10-18 μm wide at the base, 8-10 μm wide and conspicously echinulate in the below half, terminating in sterile, setiform, variously curved, pale brown to hyaline, up to 6 μm wide apical branches. The conidiophore branches bear short, fertile, dark to pale brown, verruculose, widely spaced, 1-2-septate, up to 25 μm long, 3-5 μm wide laterals. *Conidiogenous cells* polyblastic, integrated, terminal to subterminal on fertile branches, elongated, denticulate in the upper half, sometimes collapsing into cupulate form, 5-10 x 2-3 μm. *Conidia* dry, catenate, usually in branched, acropetal chains, spherical, dark brown, verruculose, aseptate, 3-5 μm diam.

On dead leaves of *Dendrocalamus strictus* Nees, Mollem, Bhagwan Mahavir Wildlife Sanctuary, Goa, India, 11 March 1999, M.D' Souza, Herb. No. IMI 386393 holotypus, GUFCC-0274, isotypus.

ADDITIONAL SPECIMENS EXAMINED: On dead leaves of *Dendrocalamus strictus*, Mollem, Bhagwan Mahavir Wildlife Sanctuary, Goa, India, 29 Dec.1999, M.D'Souza, No. GUFCC-0320. On dead leaves of *Dendrocalamus strictus*., Mollem, Bhagwan Mahavir Wildlife Sanctuary, Goa, India, 20 Sep.2000, M.D'Souza, No. GUFCC-0315.

Besides the type species, *Trichobotrys effusa* (Berk. & Br.) Petch = *T. pannosa* Penzig & Saccardo, the genus *Trichobotrys* Penzig & Saccardo so far accommodates two species, namely *T. ipomoeae* Sawada and *T. trechispora* Petch (Ellis, 1971; Morgan-Jones et al., 1987; Hawksworth et al., 1995). The genus is characterised by mononematous conidiophores producing catenate, dark brown, spherical and echinulate conidia on fertile, smooth, short, lateral branches with polyblastic conidiogenous cells. In the type species, *T. effusa,* the conidiophore is setiform, not dichotomously branched, and the fertile lateral branches are smooth, often unciform and 0-1-septate, arise directly on the main stipe, the characters which *T. ipomoeae* and *T. trechispora* largely share. In *T. ramosa,* the conidiophore is dichotomously branched with the numerous branches terminating in setiform sterile ends. The fertile lateral branches are short, straight, 1-2-septate, pale brown towards the apex and arise only from the primary and secondary branches of the conidiophore. The fertile branches are always verrucose.

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A Nomenclator of Torula Pers.:Fr. and Torula Sensu Turpin

J. L. Crane

Illinois Natural History Survey, 607 East Peabody Drive, Champaign, Illinois 61820-6970, U.S.A.

Abstract

This nomenclator is an index of 520 names published in *Torula* through the year 2000 and includes the source of publication, nomenclatural history, type citation and repository when located. A total of 57 lectotypes are designated to fix the application of names.

Keywords: Hyphomycetes, Blastomycetes

Introduction

The genus *Torula* Pers.:Fr. was established by Persoon (1795) with *Torula monilis* Pers. and *T. fructigena* Pers. as the only species. From the generic and specific descriptions, it was the intent of Persoon to include in this genus Hyphomycetes with dark or subhyaline, moniliform, 1-celled conidia. Later, Persoon (1801) de-emphasized the color of the mycelium and conidia in *Torula* as a distinct generic character by reducing the genus to subgeneric rank under *Monilia* Pers.:Fr. The name *T. monilis* was changed to *Monilia herbarum* Pers. to avoid a tautonym and this species was included in the subgenus *Torula* along with *M. fructigena* (Pers.) Pers., and *M. antennata* Pers. presently *Bispora antennata* (Pers.:Fr.) Mason. Link (1816) reestablished *Torula* as a distinct genus in the original sense of Persoon with *T. herbarum* and *T. tenera* Link presently *Xylohypha nigrescens* (Pers.:Fr.) Mason. The generic name and *T. herbarum* were later sanctioned by Fries (1832). The generic concept of *Torula* as defined by Persoon and Link was accepted by subsequent mycologists into the 20th century as can be seen by the following abbreviated, chronological history of the generic diagnosis:

> Nees (1816) *Torula*, p. 72. Fibers ... joined together by round, light, and irregularly separated grains.
>
> Martius (1817) *Torula*, p. 357. Spores subglobose or ovate, seriate in moniliform threads. *T. herbarum* ... black, segments subglobose ...
>
> Gray (1821) *Torula*, p. 557. Thalli threadlike ... jointed; joints globular. *T. herbarum*. Thalli black ...

> Fries (1832) *Torula*, p. 311. Spores moniliform-linked in erect tufts somewhat opaque, without pedicel, easily detached ...
>
> Corda (1837) *Torula*, p. 8. Thalli and spores with simple joints ... *T. herbarum*. Spores dark brown.
>
> Rabenhorst (1844) *Torula*, p. 34. Spores moniliform, ..., filaments ... finally fragmenting into their segments. Mostly of black color.
>
> Saccardo (1880) *Torula*, p. 21 and 1886, p. 247. Conidia arranged in chains, seceding singly or in a series ... continuous, dark brown or black.
>
> Lindau (1906) *Torula*, p. 567. Conidia ... regularly combined in chains which finally break down into one-cell segments or short jointed pieces, mostly black, brown ...

Ciferri (1925), Trotter (1931), Clements & Shear (1931), and Doidge (1935) accepted *Torula* in the sense of Saccardo (1886). Thus, the first complicating factor in defining the genus *Torula* was the consensus among mycologists that the genus consisted of Hyphomycetes with moniliform chains of 1-celled, dark or subhyaline conidia. Under this broad generic concept a heterogenous assemblage of Hyphomycetes have been described in the genus.

Mason (1941) selected *T. herbarum* as the lectotype of *Torula*. He noted that while some conidia in this species fall apart as single cells, most when released were phragmoconidia. Mason and subsequent workers such as S. Hughes (1953, 1958), Joly (1964), Barron (1968), M. Ellis (1971, 1976), D. Ellis & Griffiths (1975), and Crane & Schoknecht (1977) have contributed to narrowing the generic concept.

As presently conceived *Torula* consists of Hyphomycetes with polyblastic or monoblastic conidiogenous cells from which branched, acropetal chains of dark phragmoconidia develop. The apical cell of each conidium within the chain may be conidiogenous. The conidiogenous cells are sphaerical to cupulate, verrucose or echinulate. The distal fertile part is thin-walled, and frequently collapses. The proximal sterile portion is dark brown or reddish-brown, and thick-walled. Mason has referred, in private correspondence, to this unique conidiogenous cell as the "corona cell". Thus, the uniqueness of the conidiogenous cell and the branched chains of dark phragmoconidia, the apical cell of which may become conidiogenous, are the distinguishing characters of the genus *Torula*. In this restricted sense, only *T. herbarum*, the forma *quaternella* = *T. verrucosa* and a few undescribed species belong to this genus. Genera closely related to *Torula* and having coronate conidiogenous cells are *Dwayabeeja* Subram., *Bahuchashaka* Subram., and *Bahusaganda* Subram. *Polyschema* H.P. Upadhyay lacks corona cells but is considered allied to *Torula*. The named species and varieties described in *Torula* represent 377 hyphomycetes, 2 coelomycetes and 6 obligate synonyms. The hyphomycete species in *Torula* represent 35 genera which for the most part have brown, catenate conidia. The most common of these are *Xylohypha* (Fr.) S. Hughes represented by 15 species, *Taeniolella* S. Hughes by 13 species, and *Bispora* Corda with 9 species. *Wallemia sebi* (Fr. : Fr.) Arx, a probable basidiomycete fide Moore (1986), is represented by 12 species. Four species of *Torula* are sooty molds. It is interesting to note that *T.*

herbarum has 22 synonymous species and 6 synonymous varieties described in *Torula*.

The second complication to the generic concept of *Torula* was introduced by Turpin (1838) who applied the name *Torula cerevisiae* (=*Saccharomyces cerevisiae* Meyen ex E.C. Hansen) to an asporogenous yeast found in beer. Subsequently, many microbiologists either considered Turpin to have established a new genus or they felt that usage should dictate the use of *Torula* sensu Turpin non Persoon. Eventually, *Torula* sensu Turpin included a heterogenous assemblage of 135 species of yeasts. Pasteur (1876) employed *Torula* for yeast fungi producing small quantities of alcohol. Hansen (1883) regarded *Torula* as yeast cells similar to *Saccharomyces* but which do not form endospores or develop typical mold growth. Guilliermond (1912) placed the genus *Torula* in the provisional group of yeasts which do not form ascospores.

Berlese (1895) studied the different species of yeasts capable of producing alcoholic fermentation and proposed the genus *Torulopsis* for those species described in *Torula* sensu Turpin, Pasteur and Hansen. Presently, many of the yeast and yeast-like fungi described in *Torula* have been accommodated in *Torulopsis* Berl., *Rhodotorula* F.C. Harrison, *Candida* Berkhout, *Cryptococcus* Vuill., *Sporobolomyces* Kluyver C.B. Niel, *Moniliella* Stolk & Dakin, and *Geotrichum* Link. However, 47 species of yeasts described in *Torula* have not been re-examined and are listed in this nomenclator as belonging to the Blastomycetes.

This nomenclator is intended as a precursor to a revision of the genus *Torula* Pers.:Fr. It is an index to the names published in the genus in the original sense of Persoon (Hyphomycetes) or sensu Turpin (Blastomycetes). It also includes teleomorph infomation when known.

1. ***T. abbreviata*** Corda, Icon. Fung. 1:8. 1837. Holotype: Flocci regidi breve. [scr. Corda] (PR 155675!). Isotype: As a microscopic preparation. (DAOM 49428!). ≡*Hormiscium abbreviatum* (Corda) Bon., Handb. Allg. Myk., p. 33. 1851. =*T. herbarum*, fide S. Hughes, Canad. J. Bot. 36:818. 1958.
2. ***T. abbreviata*** Corda var. ***sphaeriaeformis*** Berk. & Br., Ann. Mag. Nat. Hist. 2, 5:461. 1850. Holotype: On decorticated branches of *Pinus sylvestris*, Wraxall, Som[erset], (K!). The type consists of two pieces of wood with *Coniochaeta* sp.
3. ***T. abbreviata*** Corda forma ***strobilina*** Ferraris & Tonelli, Flora Ital. Crypt. Pars 2: Fungi. Hyphales. Mucedinaceae. Fasc. 10:869. 1913. Type: Not located.
4. ***T. aceti*** (Pasteur) Sacc., Atti. Accad. Sci. Ven.-Trent.-Istr. Padua 5:315. 1876. Combination not formally made here. The combination is used as a synonym of *Bacterium aceti* (Kütz.) Lanzi by Sacc., Syll. Fung. 8:1021. 1899. ≡*Mycoderma aceti* Pasteur, Ann. Sci. École. Norm. Supér. 1:125-132. 1864. =*Acetobacter aceti* (Beij.) Beij.
5. ***T. acclotiana*** Kufferath, Nom. nud. Art. 32.1. ICBN. ≡*Rhodotorula acclotiana* Harrison, Trans. Roy. Soc. Can. Ser. 3, 22(Pt. 2, Sec. 5):192. 1928. =*Rhodotorula rubra* (Demme) Lodder, fide Lodder, The Yeasts, a Taxonomic Study, ed. 2, p. 1216. 1970. =*Rhodotorula mucilaginosa* (A. Jörg.) F.C. Harrison fide Fell & Statzell-Tallman in Kurtzman & Fell, The Yeasts, a Taxonomic Study, ed. 4, p. 821. 1998.

6. ***T. acidophila*** Owen & Mobley, Food Res. 13:281. 1948. =Blastomycete. =*T. acidula* F.C. Harrison, Trans. Roy. Soc. Can. Ser. 3, 21(Pt. 2, Sec. 5):356. 1927.
7. ***T. acidula*** Harrison, Trans. Roy. Soc. Can. Ser. 3, 21(Pt. 2, Sec. 5):356. 1927. =Blastomycete.
8. ***T. acrosporium*** Corda in Sturm's Deutschl. Flora III (Pilze), Bd. 2, Hefte 8:75. 1829. Type: Not seen. =*Acrosporium monilioides* Nees, Das System der Pilze:53. 1816/1817. ≡*Oidium monilioides* (Nees) Link in Willd. Spec. Plant. IV, 6(1):122. 1824. =*Acrosporium* anamorph of *Blumeria graminis* (DC.) Speer fide Hughes, Canad. J. Bot. 36:733. 1958. [as*Erysiphe graminis*].
9. ***T. adnata*** Fuckel, Fungi Rhenani No. 1513. Anno 1865. [as *Torula* (*Antennaria*) *adnata* Fuckel], Hedwigia 5:24. 1866. **Lectotype designated herein**: *Cardaminis pratensis* caules aridos. Oestrich (Nassau), Leg. Fuckel, Fungi Rhen. No. 1513. (G!). Isolectotypes: (FH!, K!, L!, NY!, UPS!). =Mycelia sterilia, fide Hughes, Canad. J. Bot. 36:819. 1958. Confirmed in material at (G and L). Material at (NY) also contains *Cladosporium macrocarpum* Preuss. Material at (UPS) contains a pycnidial fungus.
10. ***T. aequalis*** Berk. & Curt. in Berk., Grevillea 3:14. 1874. On bark of *Cyrilla*, Car. Inf. No. 5020 (K). =*Bispora betulina* (Corda) S. Hughes, Canad. J. Bot. 36:740. 1958.
11. ***T. aequivoca*** Corda, Icon. Fung. 2:8. 1838. ≡*Oospora aequivoca* (Corda) Sacc. & Vogl., Syll. Fung. 4:17. 1886. Type not located.
12. ***T. aeria Saito*** [as *aerius*], Jap. J. Bot. 1:41. 1922. Type strain: CBS 155. ≡*Torulopsis aeria* (Saito) Lodder, Verh. Kon. Akad. Wetensch. Amsterdam. Verh. Afd.Natuurk. Sec. 2, Vol. 32:161. 1934. ≡*Paratorulopsis aeria* (Saito) Novák & Zsolt, Acta Bot. Acad. Sci. Hung. 7:141. 1961. Nom. Inval. Art. 33.3. ICBN. ≡*Cryptococcus albidus* (Saito) C.E. Skinner var. *aerius* (Saito) Phaff & Fell, inLodder, The Yeasts, a Taxonomic Study, ed. 2, p. 1093. 1970.
13. ***T. alactosa*** Kluyver ex F.C. Harrison, Trans. Roy. Soc. Can. Ser. 3, 22(Pt. 2, Sec.5):210. 1928. The name first appeared on cultures and in the catalogs of CBS as *Torula alactosa* Kluyver. Considered a strain of *Torulopsis holmii* (Jorgenson) Lodder, Verh. Kon. Akad. Wetensch. Amsterdam Afd. Naturk. Sect. 2, 32:147. 1934. =*Candida holmii* (A. Jörg.) S.A. Mey. & Yarrow fide Vaughan-Martini & Martini in Kurtzman & Fell, The Yeasts, a Taxonomic Study, ed. 4, p. 364. 1998.
14. ***T. alba***, Nom. nud. Art. 32.1. ICBN. This is strain F of *Sporobolomyces salmonicolor* (Fischer & Brebeck) Kluyver & van Niel. and was isolated from mixed cultures sent by Saito to van Niel. in 1923, fide Lodder, The Yeasts, a Taxonomic Study, ed. 2, p. 854. 1970.
15. ***T. alba*** Pers. in C.F. Reed & D.F. Farr, Index to Sacc. Syll. Fung. Vols. I-XXVI in XXIX 1882-1972, p. 813. 1993. An error for *T. alta* (Ehrenb.:Fr.) Pers., Mycol. Europ. 1:22. 1822.
16. ***T. alba*** Preuss, Linnaea 25:73. 1825. ≡*Oospora alba* (Preuss) Sacc. & Voglino, Syll. Fung. 4:13. 1886. Type: Auf Weinreben (B). =*Geotrichum candidum* Link fide Carmichael, Mycologia 49:827. 1957. Not identifiable, fide W. Gams, *Cephalosporium*-artige Schimmelpilze (Hyphomycetes), p. 204. 1971.
17. ***T. "alba vel ubilicata"*** Rivolta, Dei parassiti vegetali, come introduzion allo studie delle malattie parassitarie e delle alterazioni dell'alimento degli

animali domestici. Torino, p. 439. 1873. ≡*Oospora umbilicata* (Rivolta) Sacc., Syll. Fung. 10:512. 1892. Type not maintained. Probably *Scopulariopsis* sp., fide W. Gams, *Cephalosporium*-artige Schimmelpilze (Hyphomycetes), p. 220. 1971.

18. ***T. albida*** Saito, Jap. J. Bot. 1:43. 1922. Type culture: CBS 142. ≡*Torulopsis albida* (Saito) Lodder, Verh. Kon. Ned. Akad. Wetensch., Afd. Natuurk., Tweede Section 32:163. 1934. ≡*Cryptococcus albidus* (Saito) C.E. Skinner, Amer. Midl.Naturalist 43:249. 1950. ≡*Cryptococcus albidus* (Saito) C.E. Skinner var. *albidus*, fide Lodder, The Yeasts, a Taxonomic Study, ed. 2, p. 1093. 1970.
19. ***T. alicola*** Ferraris, Flora Ital. Crypt., Pars 1: Fungi. Fasc. 10:870. 1913. Type not located.
20. ***T. allii*** (Harz.) Sacc., Syll. Fung. 4:260. 1886. ≡*Xenodochus allii* Harz., Bull. Soc. Imp. Naturalistes Moscou 44:134. 1871. Type lost. Considered a synonym of *Trichocladium opacum* (Corda) S. Hughes, fide D.H. Ellis, Trans. Brit. Mycol. Soc. 70:67. 1978.
21. ***T. alnea*** Peck, New York State Mus. Bull. (Rept. State Bot.) 25:89. 1873. Type: (NYS). =*Taeniolella alta* (Ehrenb.) S. Hughes, Canad. J. Bot.
22. ***T. alni*** Lindau in Rabenh. Krypt.-Fl. ed. 2, Erster Band, VIII Abt., p. 585. 1906. Holotype: Auf dürren Ästchen von *Alnus glutinosa* am Grünewaldsee bei Berlin. Leg. Lindau in Mai. (B!). =*Trimmatostroma betulinum* (Corda) S. Hughes.
23. ***T. alpestris*** R. Ludwig, Bull. Soc. Bot. Genève Ser. 2, 11:446, Fig. 20-22, 460, Fig. 1. 1917. =Blastomycete.
24. ***T. alpina*** Fourç. in Roum., Fungi Sel. Exs. No. 4188. 1887; Rev. Mycol. 9:154. 1887. **Lectotype designated herein**: Sur le thalle de l'*Evernia occhroleuca* Fr. =*Alectoria ochroleuca* (Hoffm.) Massal., Rochers du Col de Venasque, Pyrénées, Spain. (ILL!). Isolectotypes: (NY!, K!). No identifiable fungi were seen on this material. Name based on sterile mycelium fide Hawksworth, Bull. Brit. Mus. Nat. Hist. 6(3):287. 1979.
25. ***T. alpina*** Grüss, Nom. nud. Art. 32.1. ICBN. Type culture: Grüss, July 1931 (CBS). =*Cryptococcus albidus* (Saito) C.E. Skinner var. *albidus*, fide Lodder, The Yeasts, a Taxonomic Study, ed. 2, p. 1095. 1970. =*Cryptococcus albidus* (Saito) C.E. Skinner fide Fell & Statzell-Tallman in Kurtzman & Fell, The Yeasts, a Taxonomic Study, ed. 4, p. 759. 1998.
26. ***T. alta*** (Ehrenb.:Fr.) Pers., Mycol. Europ. 1:22. 1822. ≡*Hormiscium altum* Ehrenb.:Fr., Sylvae Myc. Berol. 10, 22. 1818; Fries, Syst. Mycol. 3:301. 1832. Type: (B). ≡*Monilia alta* (Ehrenb.:Fr.) Link in Willd., Sp. Pl., IV, 6(1):126. 1824. ≡*Taeniola alta* (Ehrenb.:Fr.) Bon., Handb., p. 36. 1851. ≡*Taeniolella alta* (Ehrenb.:Fr.) S. Hughes, Canad. J. Bot. 36:817. 1958.
27. ***T. altaica*** Nannizzi, Atti. Accad. Sci. Siena 10, 3:962. 1928. Holotype: In petiolis putrescentibus foliorum *Saxifragae crassifoliae* in Siberia, Austr., Mt. Karakol, [Asia], 17 Jun. 1923. (SIENA!). =*Torula herbarum* (Pers.) Link:Fr.
28. ***T. alternata*** Fr.:Fr., Syst. Mycol. 3:500. 1832. Neotype: (L 910,262-129!) selected by Simmons, Mycologia 59:72. 1967. ≡*Alternaria alternata* (Fr.:Fr.) Keissler, Beih. Bot. Centralbl. Abt. 2, 29:4333. 1912. Type of *Alternaria* Nees by conservation.

29. *T. **amara*** F.C. Harrison, Zentralbl. Bakteriol., 2 Abt. 9:212. 1902. =Blastomycete.
30. ***T. ambrosiae*** (Peck) S. Hughes, Canad. J. Bot. 36:818. 1958. Holotype: On dead stems of *Ambrosia trifida* L., Louisville, Kansas, Sept., Leg. E. Bartholomew. (NYS!). ≡*Hormiscium ambrosiae* Peck, New York State Mus. Bull. 150:55. 1911.
31. ***T. ampulla*** F.C. Harrison, Trans. Roy. Soc. Can. Ser. 3, 21(Pt. 2, Sec. 5):359. 1927. =Blastomycete.
32. ***T. angusta*** F.C. Harrison, Trans. Roy. Soc. Can. Ser. 3, 21(Pt. 2, Sec. 5):357. 1927. =Blastomycete.
33. ***T. anisospora*** Sacc., Ann. Mycol. 12:314. 1914. Holotype: In caule languido v. moriente *Restionis* sp. in Australia occid. 1914, Comm. P. Hariot. (PAD!). =*Arthrinium* sp.
34. ***T. annulata*** F.C. Harrison, Trans. Roy. Soc. Can. Ser. 3, 21(Pt. 2, Sec. 5):362. 1927. =Blastomycete.
35. ***T. antennata*** (Pers.) Pers.:Fr., Traité Champ. Comest, Paris, p. 59. 1818; Fries, Syst. Mycol. 3:501. 1832. ≡*Monilia antennata* Pers., Syn. Meth. Fung, p. 694. 1801. Type: (L 910,267-937!, UPS!). ≡*Hormiscium antennatum* (Pers.) Bon., Handb. Allg. Myk., p. 34. 1851. ≡*Bispora antennata* (Pers.) Mason, Nat.Hist. Scarborough Distr. 1:158. 1953, Nom. inval. Art. 33.3. ICBN. ≡*B. antennata* (Pers.) Mason in Hughes, Canad. J. Bot. 31:582. 1953.
36. ***T. antennata*** (Pers.) Pers.:Fr. forma *corticola* Roum., Fungi Sel. Exs. No. 1778. Anno1881. Nom. nud. Art. 32.1. ICBN. Type: Écorce morte du *Corylus avellanna*L. Malmédy, Belgique, (L 910,252-1054!, ILL!). =*Trimmatostroma salicis* Corda.
37. ***T. antigua*** Corda, Icon. Fung. 2:9. 1838. Holotype: (PR 155722!). Isotype: Microscopic prep: DAOM 49941!). ≡*Hormiscium antiguum* (Corda) Sacc., Syll. Fung. 4:264. 1886. Not a *Torula*; position uncertain.
38. ***T. antracina*** Rabenh., Nom. nud. Art. 32.1. ICBN. Fungi Europ. Exs. No. 572?. Edition, century, and date are unknown. Holotype: In pini truncis radicibusque denudatis. (B!). Isotype: (FH!).
39. ***T. arbuscula*** Corda, Icon. Fung. 2:9. 1838. Type: (PR). ≡*Hormiscium arbuscula* (Corda) Sacc., Syll. Fung. 4:266. 1886. ≡*Peyronelia arbuscula* (Corda) S. Hughes, Canad. J. Bot. 36:795. 1958.
40. ***T. aromatica*** F.C. Harrison, Trans. Roy. Soc. Can. Ser. 3, 21(Pt. 2, Sec. 5):376. 1927. =Blastomycete.

41 ***T. arta*** F.C. Harrison, Trans. Roy. Soc. Can. Ser.3, 21(Pt 2, Sec. 5):370. 1927. =Blastomycete.

42. ***T. asperula*** Sacc., Michelia 2:560. 1882. Holotype: In charta uda putri, Mantova, Majo 1876. (PAD!). ≡*Scopulariopsis asperula* (Sacc.) S. Hughes, Canad. J. Bot. 36:803. 1958.
43. ***T. atra*** Sappa & Mosca, Allionia 2:176. 1954. Type not located. Possibly based on terminal and interculary, thick-walled hyphae.
44. ***T. aurantiaca*** Saito, Jap. J. Bot. 1:45. 1922. Type strain: CBS 317 from Saito, dated 1923. ≡*Torulopsis aurantiaca* (Saito) Cif. & Red., Atti Ist. Bot. Univ. Pavia 3, 2:264. 1925. ≡*Rhodotorula aurantiaca* (Saito) Lodder, Verh. Kon. Akad. Wetensch. Amsterdam Afd. Natuurk. Sect. 2, 32:78. 1934.

≡*Rhodotorula glutinis* (Fresen.) F.C. Harrison var. *aurantiaca* (Saito) Hasegawa, J. Ferment. Technol. (Japan) 36:200, 201, 202. 1958.

45. ***T. aurea*** (Pers.) Corda, in Sturm's, Deutschl. Flora III (Pilze), Bd. 2, Hefte 8:79-80. 1829. ≡*Trichoderma aureum* Pers., Obs. Mycol. 1:99. 1796. ≡*Oidium aureum* (Pers.) Link:Fr., Mag. Ges. Naturf. Freunde, Berlin 3:18. 1809; Syst. Mycol. 3:429. 1832. ≡*Oospora aurea* (Pers.:Fr.) Wallr., Flora Crypt. Germ., 2:183. 1833. ≡*Trichosporum aureum* (Pers.:Fr.) Fr., Summa Veg. Scan. 2:492. 1849. [as Lk.]. =*Sporotrichum aureum* Link:Fr.
46. ***T. aurea*** Saito, Jap. J. Bot. 1:44. 1922. Nom. illeg. Art. 53.1. ICBN. Type strain: CBS 942 from Saito, dated September 1923. =*Cryptococcus laurentii* (Kuff.) C.E. Skinner var. *flavenscens* (Saito) Lodder & Kreger-van Rij, fide Lodder, The Yeasts, a Taxonomic Study, ed. 2, p. 1120. 1970. =*Cryptococcus laurentii* (Kuff.) C.E. Skinner fide Fell & Statzell-Tallman in Kurtzman & Fell, The Yeasts, a Taxonomic Study, ed. 4, p. 759. 1998.
47. ***T. bambusae*** Pat. & Gaillard, Bull. Soc. Mycol. France 3:125. 1888. Holotype: Sur bambou pourri. Caracas, [Venezuela], Mars. 1re Ser. No. 7. p.p. (FH!). Isotypes: (K!, PC!). =*Arthrinium arundinis* (Corda) Dyko & Sutton, Mycotaxon 8:119. 1979.
48. ***T. bantiana*** Sacc., Ann. Mycol. 10:320. 1912. Type: In tumore (granulomate) cerebrali, habitu melanotico, feminae, causa ejusdem tumoris emortuae Florentiae, hieme 1912. Only illustrations of the type exist at PAD. ≡*Cladosporium bantianum* (Sacc.) Borelli, Rivista Anat. Pat. Oncol. 17:618. 1960.
49. ***T. basicola*** Berk. & Br., Ann. Mag. Nat. Hist. Ser. 2, 5:461. 1850. Holotype: On peas and *Nemophila auriculata* , King's Cliffe, Great Britain, (K!). ≡*Thielaviopsis basicola* (Berk. & Br.) Ferraris, Flora Ital. Crypt. Pars 1, Fasc. 8:233-234. 1912. Based on the thallic-arthric anamorph of *Chalara elegans* Nag Raj & Kendrick, A monograph of *Chalara* and allied genera, pp. 111-113. 1975. =*Trichocladium basicola* (Berk. & Br.) Carmichael, in Carmichael, Kendrick & Sigler, Genera of Hyphomycetes (Edmonton, Canada):185. 1980.
50. ***T. bergeri*** Langer., Ann. Parasitol. Humaine Comp. 24:597. 1949. Nom. inval. Art. 36.1. ICBN. Originally isolated from a case of chromomycosis in Canada. =*Phialophora bergeri* (Langer.) Cif., Manuale di Micologia Medica 2:486. 1960. =*Phialophora jeanselmei* (Langer.) Emmons, fide W.B. Cooke, Mycopathol. Mycol. Appl. 17:39. 1962. ≡*Exophiala jeanselmei* (Langer.) McGinnis & Padhye, Mycotaxon 5:347. 1977. =*Exophiala mansonii* (Castell.) de Hoog, Studies Mycol. Baarn 15:114. 1977.
51. ***T. bestae*** Pollacci, Rivista Biol. 4:317. 1922. Type: On man in Italy. ≡*Phaeoscopulariopsis bestae* (Pollacci) Ota, Jap. J. Dermatol. Urol. 23:406. 1928. Nom. Inval. Art. 34.1. ICBN. =*Scopulariopsis koningii* (Oud.) Vuill., fide F.J. Morton & G. Smith, Mycol. Pap. I.M.I. 86:46. 1963.
52. ***T. beticola*** Neuwirth, Zeitschr. Zucherindustr. Českoslov[ensko] Republ. Prague 49:483. 1925. Type: Ad betae radices. Not located. From the de scription and illustration, this species is not a *Torula*.
53. ***T. bigemina*** Cooke & Ellis, Grevillea 7:38. 1878. Holotype: On rotten wood. No. 3010. (K). Isotype: On rotten wood, [Newfield, N. J., Gloucester County, May 24, 1878, Leg. J.B. Ellis, Det.: Cooke]. (NY!). ≡*Cryptocoryneum*

bigeminum (Cooke & Ellis) S. Hughes, Canad. J. Bot. 36:758. 1958. =*Eversia subopaca* (Cooke & Ellis) J.L. Crane & Schokn., Mycologia 69:539-542. 1977.

54. ***T. binalis*** Cooke & Ellis [as binale], Grevillea 6:5. 1877. **Lectotype designated herein**: On decayed oak [Quercus] wood. Ellis, North American Fungi No. 36. Anno 1878. (K!). Isolectotypes: (FH!, ILL!, NY!, NYS!), =*Bispora betulina* (Corda) S. Hughes.
55. ***T. binalis*** Cooke & Ellis [as binale] var. *quarternata* , Herbarium name. Material at (FH!) on white pine board on ground, Newfield, N. J., leg. J.B. Ellis, September 20, 1878. =*Bispora betulina* (Corda) S. Hughes.
56. ***T. bisporoidea*** Höhnel, Nom. nud. Art. 32.1. ICBN. Herbarium name. Material at (FH!). =*Alysidium resinae* (Fr.) M.B. Ellis.
57. ***T. bogoriensis-rubra*** DeKruyff, Ann. Jard. Bot. Buitenzorg Suppl. 3:93. (1909) 1910. Isolated from soil in Java. =Blastomycete.
58. ***T . bombycis*** Sopp Olav, Nom. nud. Art. 32.1. ICBN, Falsely cited by Trotter in Saccardo, Syll. Fung. 25:762. 1931. As published in Sopp, Olav Johan-Olsen Monographie der Pilzgruppe *Penicillium* mit besonderer Berücksichtigung der in Norwegen Gefundenen Arten. I. Skr. Vidensk.-Selsk. Christiana, Math.-Natwrvidensk, Kl. No. 11. 1912.
59 ***T. botryoidea*** Chaborski, Bull. Soc. Bot. Geneve 2, 11:85. 1919. Type: Not located. ≡*Microblastosporon botryoideum* (Chaborski) Cif., Arch. Protistenk. 71:424. 1930.
60. ***T. botryoides*** Corda, Sturms's, Deutschl. Flora, III (Pilze), Bd. 2, Hefte 8:77. 1829. Type: Auf den Blütenstaude der *Spiraea* im Kanal'schen Garten bei Prag. Not located at PR. ≡*Oidium erysiphoides* Fr., fide Fr., Syst. Mycol. 3:432. 1832. Possibly *Acrosporium* sp.
61. ***T. botryoides*** Brooks & Hansf., Trans. Brit. Mycol. Soc. 8:134. 1923. Nom. illegit. Art. 53.1. ICBN. **Lectotype designated herein**: A dried subculture of original isolation from halibut, made by F.T. Brooks [England], (IMI 38353!). Isolectotype: Isolated from a halibut in cold storage, May 1918. CBS 143.23. ≡*Polypaecilum botryoides* Brooks & Hansf. ex Rao & de Hoog, Persoonia 8(2):202. 1975.
62. ***T. bowdichiae*** Petrak, Sydowia 1:308. 1947. Holotype: Auf Blättern von *Bowdichia virgilioiodes*, Rio Grande di Norte, Natab. Brasilien, September 23, 1927, Leg. H. Zerny (W!). Isotypes: (NY!, PR 777167!). ≡*Xylohypha bowdichiae* (Petrak) J.L. Crane & Schokn., Mycologia 73:86. 1981.
63. ***T. brachiata*** Ellis & Barth., J. Mycol. 8:176. 1902. Holotype: On dead branches of *Symphoricarpus occidentalis*, Steamboat, Colorado, July 15, 1902. No. 938 (FH!). ≡*Papulaspora brachiata* (Ellis & Barth.) J.L. Crane & Schokn., Mycologia 67:667. 1975.
64. ***T. brettanomyces*** Claussen, in Guillerm., Les Levures, Paris, p. 430. 1912. =Blastomycete.
65. ***T. brevis*** (Bon.) Sacc. & Trav., Syll. Fung. 20:962. 1911. ≡*Xenodochus brevis* Bon., Handb. Taf. VIII. Fig. 174. 1851. A Nom. nov. for *T. abbreviata* Corda, Icon. Fung. 4:25, Pl. 6, Fig. 80. 1840 which is based on *T. abbreviata* Corda, Ibid. 1:8. 1837. =*T. herbarum* (Pers.) Link:Fr.

66. *T.* ***brevissima*** Berk. & Curt, in Berk., Grevillea 3:14. 1874. **Lectotype designated herein**: In *Hibiscis syriaci* corticem, No. 2640, June 1849, Society Hill, S. C. (K!). Isolectotypes: (FH!), microscopic preparation: DAOM 44545!). =*T. herbarum* (Pers.) Link:Fr.
67. *T.* ***broussonetiae*** Thüm., Boll. Soc. Adriat. Sci. Nat. Trieste 9:67. 1885. Type: In *Broussonetiae papyriferae* Vent. ramulis emortuis. Nov. Gorizia (N. 1040). Apparently lost.
68. *T.* ***bulbigera*** Bon., in Rabenhorst's, Fungi Europ. Ed. 3, Cent. 3, No. 175. 1860; Bot. Zeitung 9:195. 1861. **Lectotype designated herein**: Horford in foliis Graminum. Fungi Europ. ed. 3, Cent. 3, No. 175. Anno 1860, Leg. Bonorden, (B!) Isolectotypes: M!, L 910-252-1067!. ≡*Oidium bulbigerum* (Bonord.) Sacc. & Voglino, Syll. Fung. 4:47. 1886. =*Acrosporium* state of *Blumeria graminis* (DC.) Speer
69. *T.* ***caesia*** (Fuckel) Sacc., Syll. Fung. 4:251. 1886. ≡*Alysidium caesium* Fuckel, Symb. Mycol., pp. 349-350. 1870. **Lectotype designated herein**: Auf faulendem Holz von *Fagus sylvatica*, im Herbst. Auf dem Rabenkopf bei Östrich, L. Fuckel, Fungi Rhen. Exsic. Fasc. 1, No. 73. Anno 1863 (G!). Isolectotype: (FH!). =*Xylohypha ferruginosa* (Corda) S. Hughes.
70. *T.* ***caligans*** (Bat. & H.P. Upadhyay) M.B. Ellis, Dematiaceous Hyphomycetes, Commonwealth Agricultural Bureaux, Kew. p. 337. 1971. ≡*Bahusandhika caligans* Batista & H.P. Upadhyay, Atas Inst. Micol. 2:321. 1965. Holotype: Isolated from soil at Caruaru, Pernambuco, [Brazil]. 11 Aug. 1964. Leg. E. de Barros Correia. (URM 1955). Isotype: IMI 115285!.
71. *T.* ***?callispora*** Speg., Anales Soc. Ci. Argent. 10:164. 1880. Holotype: In caulibus putrescentibus in nemorosis prope Recolecta, 18-VII-1880 (LPS 12.753!). ≡*Hormiscium callisporum* (Speg.) Grove, J. Bot. 50:16. 1912. =*Torula herbarum* (Pers.) Link:Fr.
72. *T.* ***canceratica*** Strasser, Verh. Zool.-Bot. Ges. Wien 65:217-218. 1914. Presumed type: Auf Larchen, Sonntagsberg, N. Österreich [Lower Austria], March 17, 1913, P.P. Strasser (FH!). Note: Date given in description is April 1913; that on specimen is 17 March 1913. The species may be based on the hyphae of a sooty mold.
73. *T.* ***? candida*** Opiz, Lotos 5:216. 1855. Authentic material at Prague (PR 704571!), leg. Veselsky. It consists of dry goat dung with a white inorganic deposit on surface. The type is attributed to J. Kalmus in the protologue.
74. *T.* ***candida*** (Wallr.) Opiz sensu Sacc., Atti. Soc. Venet.-Trent. Sci. Nat. Padova 2:225. 1873, Mycologiae Venetae. Patavii, p. 177. 1873. Nom. illeg. Art. 53.1. ICBN. ≡*Oospora candidula* Sacc., Fungi Ital. Delin. Tab. 880. 1881; Michelia 2:545. 1882. Nec *T. candida* Opiz, 1855. Holotype: In foliis *Aceris pseudopl*. Selva, [Aut. 18]74. (PAD 2689!). =*Myrothecium* sp.?, fide W. Gams, *Cephalosporium*-artige Schimmelpilze (Hyphomycetes), Stuttgart, p. 206. 1971.
75. *T.* ***candida*** Saito, Jap. J. Bot. 1:41. 1922. Nom. illeg. Art. 53.1. ICBN. Type strain: CBS 940. ≡*Torulopsis candida* Saito ex Lodder, Verh. Kon. Ned. Akad. Wetensch., Afd. Natuurk., Tweede Section 32:164. 1934. ≡*Cryptococcus candidus* (Saito ex Lodder) C.E. Skinner, Amer. Midl. Naturalist 43:249. 1950. ≡*Torulopsis candida* (Saito) Coudert, Guide Pratique de Mycologie

Médicale, Paris,p. 246. 1955. Nom. illeg. Art. 52.1. =*Candida famata* (F.C. Harrison) Meyer & Yarrow, Int. J. Syst. Bacteriol. 28:612. 1978. ≡*Candida saitoana* Nakase & M.Suzuki, J. Gen. Appl. Microbiol. 31:85. 1985. See Meyer, Payne Yarrow in Kurtzman & Fell, The Yeasts, a Taxonomic Study, ed. 4, p. 546. 1998. Also listed in this work as a synonym of *C. famata* (F.C. Harrison) S.A. Mey. & Yarrow var. *famata* on p. 161.

76. ***T. caraganae*** Thüm., Bull. Soc. Imp. Naturalistes Moscou 53:209. 1878; Mycotheca Universalis Cent. 16, No. 1563. Anno 1880. Holotype: In *Caraganae arborescentis* Lam. cortice vivo pr. Minussinsk, No. 208. Not located. Presumed Isotypes: Sibira occidentalis, Minussinsk in *Caraganae arborescentis* Lam. cortice vivo, 1876 et 1877, Thümen, Myc. Univ. No. 1563. (B!, FH!, ILL!, K!, NY!, L 910.252-1047!). Not a *Torula*. Specimens contain clumps of dark, thick-walled cells.
77. ***T. carbonaria*** (Schltdl.) Corda, Icon. Fung. 3:5. 1839. ≡*Xenodochus carbonarius* Schltdl., Linnaea 1:237. 1826. (Uredinales). ≡*Phragmidium carbonarium* (Schltdl.) G. Winter, Rabenh. Krypt.-Fl. ed. 2, 1(1):227. 1881.
78. ***T. caricina*** Ellis & Dearn, Proc. Roy. Canad. Inst. N. S. 1:90. 1877. Holotype: On dead leaves of *Carex lupulinus*, London, Canada, September 1896. Herb. D. No. 2403 (DAOM!). Isotype: Fungi Columbiani No. 1163. (ILL!, NY!). =*Rutola graminis* (Desm.) J.L. Crane & Schokn.
79. ***T. caseavanus*** Baba, Bull. School Agric. Taihoku Imp. Univ. 4:8-14. 1943. Nom. .nud. =Blastomycete.
80. ***T. casei*** (Desm.) Corda, Icon. Fung. 2:8. 1838. ≡*Sporendonema casei* Desm., Ann. Sci. Nat. (Paris) Ser. 1, 11:246-249. 1827; Recueil Trav. Soc. Sci. Lille 1826/1827:185-188. 1827. Type: Lost. Authentic material: (FH!). See Sigler & Carmichael, Mycotaxon 4:404-406. 1976.
81. ***T. casei*** (Desm.) Corda var. *alba* Rabenh., Klotzschii Herb. Vivum Mycol. Fung ed.I, Cent. 16, No. 1568. Anno 1851. Nom. nud. Art. 32.1. ICBN. Type: (B!, L!,PR!). Material from B and PR 777169 appears to be *Chrysospermum pruinosum* (Gilman & Abbott) J.W. Carmich. The L material L 910.252-1053, L 910.252-1056. =*Cladosporium cladosporioides* (Fresen.) de Vries.
82. ***T. casei*** , in Lodder, The Yeasts, a Taxonomic Study, ed. 2, p. 1027. 1970. Nom. nud. Art. 32.1. ICBN. This is a strain of *Candida pseudotropicalis* (Cast.)Basgal, which was isolated in Czechoslovakia, probably from cheese. =*Candida kefyr* (Beij.) Uden & H.R. Buckley fide Rij, The Yeasts, a Taxonomic Study, ed. 3, p. 721. 1984.
83 ***T. cassavanus*** T. Baba, Bull. School Agric. Taihoku Imp. Univ. 4:8-14. 1943. Nom. Inval. Art. 36.1. ICBN. =Blastomycete.
84. ***T. (Hormiscium) caulicola (pelargonii)*** Rabenh., Klotzschii Herb. Vivum Mycol. Fung. ed. I, Cent. 20, No. 1982. Anno 1855. ≡*Hormiscium caulicola* (*pelargonii*) Rabenh., Hedwigia 1:42. 1854. **Lectotype designated herein**: In *Pelargonii caulibus*, Heime 1853/4. (PR 777171!).Isolectotypes: L 910.249-1415!, L 910.249.1416!. Based on mycelium with thick-walled cells.
85. ***"T. celtis de Bivona-Bernardi"***, in Link in Willd. Sp. Pl. Ed. 16, 6(1):128. 1824. An error for *Monilia celtis* de Biv., Stirpium Rar. Sicilia Pt. 3:18. 1815.

Authentic material: (PR 777255!, PR 777252!). =*Gliomastix murorum* (Corda) S. Hughes.

86. ***T. centaurii*** Fuckel, Hedwigia 2:133. 1863. **Lectotype designated herein**: Ad *Erythrae centaurium* [*Centaurium erythraea* Rafn.] folia viva caulesque, Oestrich (Nassau), Leg. Fuckel, Fungi Rhen. No. 66. Anno 1863. (G!). Isotype: (NY!). ≡*Hormiscium centaurii* (Fuckel) Sacc., Syll. Fung. 4:265. 1886. ≡*Taeniolina centaurii* (Fuckel). M.B. Ellis, More Dematiaceous Hyphomycetes, p. 62. 1976.
87. ***T. cephalosporioides*** van Beyma, Zentralbl. Bakteriol., 2 Abt. 96:425. 1937. Holotype: In Nymwefen von den Wurzeln einer Johannisbeere isoliert. Leg. F. Bouwens. [On *Ribes rubrum* roots, The Netherlands]. (CBS). Isotype: IMI 1447. ≡*Basitorula cephalosporioides* (Van Beyma) Arnaud, Bull. Soc. Mycol. France 69:277. 1953. =*Gliomastix murorum* (Corda) S. Hughes var. *felina* (Marchal) S. Hughes, fide C.H. Dickinson, Mycol. Pap. I.M.I. 115:16. 1968.
88. ***T. cerevisiae*** Turpin, Compt. Rend. Hebd. Séances Acad. Sci. Paris 7:379. 1838. ≡*Cryptococcus cerevisiae* (Turpin) Kuting, Species Algarum Lipsiae, pp. 146-147. 1849. Teleomorph: *Saccharomyces cerevisiae* Meyen ex Hansen, Nedel. Fra. Carlsberg Laboratoriet 2:67. 1883.
89. ***T. cerevisiae*** (Turpin) Corda, Icon. Fung. 6:5. 1854. Nom. illeg. Art. 52.1. ICBN. ?=*Mycoderma cerevisiae* Turpin, Compt. Rend. Hebd. Séances Acad. Sci. 7:379. 1838 [as Desm.]. Teleomorph: *Saccharomyces cerevisia*e Meyen ex Hansen.
90. ***T. chartarum*** Corda, Icon. Fung. 4:24. 1840. Holotype: Wohnt auf faulendem Papiere. Pr 185724. Isotype: IMI 87343. =*Gliomastix murorum* (Corda) S. Hughes fide W. Gams, *Cephalosporium*-artige Schimmelpilze (Hyphomycetes), p. 84. 1971. [as *Acremonium murorum* (Corda) W. Gams]. Not based on *Stilbospora chartarum* Ehrenb.
91. ***T. chartarum*** (Link) Lindau, Rabenh. Krypt.-Fl. ed. 2, 1(8):591. 1906. Nom. illeg. Art. 53.1. ICBN. Based on *T. chartarum* Corda. Lindau's illustration is based on Corda's Taf. VI, Fig. 78.
92. ***T. chhatarpurensis*** Singh, Proc. Natl. Acad. Sci. India, Sect. B, 43:198-200. 1973. Holotype: Isolated from soil, Chhatarpur (M.P.) India. Col. S.S. Singh, September 24, 1965. (IMI 115294!). =*Torula deospora* (Batista & Upadhyay) de Hoog & Grenbergs.
93. ***T. chrysosperma*** Corda, Icon. Fung. 1:8. 1837. Type: Not preserved. ≡*Hormiscium chrysosperma* (Corda) Bon., Handb., p. 33. 1851. ≡*Oospora chrysosperma* (Corda) Sacc. & Voglino, Syll. Fung. 4:21. 1886. According to Corda's description and illustration, the species may be based on chains of spherical, golden conidia. Cf. *Oidium purantium* Cooke, fide W. Gams, *Cephalosporium*-artige Schimmelpilze (Hyphomycetes), p. 207. 1971.
94. ***T. cinerea*** Bon., Bot. Zeitung (Berlin) 11:284. 1853. Type: Lost. Not identifiable from the description and illustration.
95. ***T. cinereovirens*** Karst., Meddeland. Soc. Fauna Fl. Fenn. Type: On *Betula*, prope Mustiala, Finland. (H!). =*Xylohypha ferruginosa* (Corda) S. Hughes.
96. ***T. cinnabarina*** (Sprengel) Martius, Fl. Crypt. Erlang., p. 357. 1817. ≡*Monilia cinnabarina* Sprengel., Fl. Hal. Tent. Nov., p. 386. 1806. ≡*Oospora cinnabarina*

(Sprengel) Sacc. & Vogl., Syll. Fung. 4:21. 1886. ≡?*Syncoelium catenulatum* Wallr., fide Hughes, Canad. J. Bot. 36:734. 1958. [An alga].

97. ***T. cinnabarina*** A. Jörg., Die Mikroorganismen der Gärungsindustrie. 5 Auflage, Berlin, p. 403. 1909. Nom. illeg. Art. 53.1. ICBN. ?=*Sporobolomyces roseus* Kluyver & C.B. Niel fide Boekhout & Nakase in Kurtzman & Fell, The Yeasts, a Taxonomic Study, ed. 4, p. 836. 1998.

98. ***T. circinans*** Roum & Pat., Rev. Mycol. 8:156. 1886. **Lectotype designated herein**: Sur les feuilles du *Symphytum officinale*. Dreux (Eure-et-Loir). Sept. 1885. Leg. Gallet. Comm. Feuilleaubois 838. Fungi Gall. Exs. Centr. 38. No. 3796. Anno 1886. (ILL!). Isolectotype: (K!, NY!). =*Torula herbarum* (Pers.) Link:Fr. Material at (NY) contains chains of light brown rough-walled cells. Sterile mycelium was also present in these collections.

99. ***T. cisti*** Auersw. n. sp., Nom. nud. Art. 32.1. ICBN. Herbarium name. Authentic material: No 350. Sierra del Montago, Aragon 7/50. Comm. Willkommn.(K!). Specimen is in poor condition. Apparently based on mycelium of a sooty mold.

100. ***T. cistina*** Thüm., Boll. Soc. Adriat. Sci. Nat. Trieste 6:123. 1880. Holotype: In foliis vivis *Cisti monspeliensis* L., Pola, 21 Sept. 1877, Leg. G. Bolle No. 922. (B!). Based on hyphae; some material resembling *Trimmatostroma betulinum* (Corda) S. Hughes also present.

101. ***T. coccinea*** Corda, Sturm's, Deutschl. Flora III (Pilze), Bd. 2, Hefte 8:87. 1829. Presumed type: (PR 155677!). ≡*Oospora coccinea* Sacc. & Voglino, Syll. Fung. 4:21. 1886. Colonies floccose, conidia 1-celled, hyaline, catenulate, developing basipetally. Not a *Torula*.

102. ***T. colliculosa*** Berk. & Curt., Grevillea 3:14. 1874. Holotype: On bleached wood, Louisiana [U.S.A.]. Dr. Hale No. 3651. (K!). Isotype: (FH!). Dictyoseptate, brown conidia present. Not a *Torula*.

103. ***T. colliculosa*** Berk. & Curt. var. ***orbicularis*** Peck, Annual Rep. New York State Mus. 49:37. 1896. Holotype: On Hemlock [*Tsuga canadensis* (L.) Carr.], Adirondack Mts. [New York], Sept., Leg. C.H. Peck, (NYS!).

104. ***T. colliculosa*** Hartmann, Wochenschr. Brauerei 20:113. 1903. Nom Illeg. Art. 53.1. ICBN. ≡*Torulopsis colliculosa* Hartmann ex Sacc., Syll. Fung. 18:495.1906. ≡*Eutorula colliculosa* (Hartmann ex Sacc.) H. Will, Centralbl. Bakteriol., 2 Abt.,46:242. 1916. ≡*Torulopsis colliculosa* (Hartmann ex Sacc.) Coudert,Guide Pratique de Mycologia Médicale, p. 247. 1955. Nom. illeg. Art. 52.1.ICBN. ≡*Cryptococcus colliculosa* (Hartmann ex Sacc.) C.E. Skinner, Amer. Midl. Naturalist 43:248.1950. ≡*Candida colliculosa* (Hartmann ex Sacc.) Meyer & Yarrow, Int. J. Syst. Bacteriol. 28:612. 1978. Teleomorph: *Torulaspora delbrueckii* (Lindner) Lindner fide Kurtzman in Kurtzman & Fell, The Yeasts, aTaxonomic Study, ed. 4, p. 404. 1998.

105. ***T. communis*** Browne, Jour. Indust. Engin. Chem. 10:185. 1918. Nom. nud. Art. 32.1. ICBN. =Blastomycete.

106. ***T. compacta*** (Wallr.) Rabenh., Deutschl. Krypt.-Fl. 1:38. 1844. ≡*Hormiscium compactum* Wallr. Flora Crypt. Germ. 2:186. 1833. Holotype: Ad ramorum salicinorum. Thüringen. (STR!). ≡*Hendersoniella compacta* (Wallr.) S. Hughes, Canad. J. Bot. 36:779. 1958.

107. ***T. compacta*** (Wallr.) Fuckel, Symb. Mycol., p. 349. 1870. Nom. illeg. Art. 52.1. ICBN. ≡*Hormiscium compactum* Wallr., Flora Crypt. Germ. 2:186. 1833. ≡Type:(STR). ≡*Hendersoniella compacta* (Wallr.) S. Hughes, Canad. J. Bot. 36:779. 1958.

108. ***T. compniacensis*** Richon, Rev. Mycol. (Paris) 3(12):8. 1881. Nom. nud. Art. 32.1. ICBN. See *T. conglomerata* var. *compniacensis* Richon.

109. ***T. composita*** Preuss, Linnaea 24:105. 1851; Sturm's, Deutschl. Flora Abt. 3, Bd. 6:65. 1851. Type: Not available. Preuss's illustration, Tab. 33, resembles a *Taeniolella*.

110. ***T. conglobata*** Redaelli, Falsely so cited in E. Brumpt, Précis de Parasitologie Ed. 5, Pt. II, p. 1791. 1936. =*Torulopsis conglobata* Redaelli, I Miceti come Associazione Microbica nella Tubercolosi Polmonare Cavitaria. Pavia pp. 58 & 60. 1925. ≡*Candida conglobata* (Redaelli) Uden & H.R. Buckley in S.A. Meyer & Ahearn, Mycotaxon 17:297. 1983.

111. ***T. conglomerata*** Nom. nud. Art. 32.1. ICBN. var. *compniacensis* Richon, Syntypes: Sur les mures des bâtiments affectés a la distillerie des eaux, Juillet 1881, Leg. Boudoin & P. Brunaud, Fungi Selecti Gallici Exsiccati Cent. 17, No. 1695. Anno 1881. (ILL!, L 910.252-598!). Nom. nud. ≡*T. compniacensis* Richon, Rev. Mycol. (Paris) 3(12):8. 1881. Nom. nud.

112. ***T. conglutinata*** Corda, Icon. Fung. 1:8. 1837. Type: Hab. in ligno pini putrido, prope Reichenberg, Corda (PR 1555678!). ≡*Hormiscium conglutinatum* (Corda) Bon., Handb., p 33. 1851. Type contains branched chains of verrucose, brown cells which are constricted at septa. =?*Taeniolella* sp.

113. ***T. (Trachytora) conglutinata*** Corda var. ***citricola*** Sacc., Ann. Mycol. 5:179. 1907. Holotype: Hab. in foliis dejectis *Citri Limonum* ex agro Tarvisino a cl. prof. Bennzi missis et diu loco udo servatis Patavii. Jan. 1907. (PAD!). =*Scopulariopsis brevicaulis* (Sacc.) Bainier.

114. ***T. conimbricensis*** Thüm., Inst. Revista Scien. Litt., Coimbra (Coimbra Univ. Ist. Coimbra). 27:16. 1879. Holotype: In *Agaves americanae* L. foliis languidis emortuisve, Coimbra. 12. 78. No. 300, 306. Leg: Möller (K!). Not identifiable.

115. ***T. convoluta*** Harz, Bull. Soc. Imp. Naturalistes Moscou 44(1):134. 1871. Type:No type or authenticated material available. =*Gliomastix murorum* (Corda) S. Hughes, Canad. J. Bot. 36:769. 1958.

116. ***T. convolvuli*** Esfand., Sydowia 5(316):370. 1951. Type: Auf faulenden Stengeln von *Convolvulus* sp. Biaban: Bahmedi, Iran. Leg. Behboudi, Feb. 21, 1949. Det.: Esfandiari (IRAN!). ≡*Pseudotaeniolina convolvuli* (Esfand.) J.L.Crane & Schokn., Mycologia 78:88. 1986.

117. ***T. corallina*** Saito, J. Bot. (Tokyo) 1:47. 1922. ≡*Torulopsis corallina* (Saito) Cif. & Redaelli, Atti Ist. Bot. Univ. Pavia 3, 2:256. 1925. Type: Strain (CBS). ≡*Rhodotorula corallina* (Saito) F.C. Harrison, Proc. & Trans. Roy. Soc. Canada Ser. 3, 22(Pt. 2, Sec. 5):197. 1928. =*Rhodotorula mucilaginosa* (A. Jörg.) F.C. Harrison fide Fell & Statzell-Tallman in Kurtzman & Fell, The Yeasts, aTaxonomic Study, ed. 4, p. 820. 1998.

118. ***T. corii*** Richon., Cat. Champ. Marne p. 436. 1889. ≡*Oospora corii* (Richon.) Sacc., Syll. Fung. 10:514-515. 1892. Type: Not located.

See Errata

119. ***T. coriicolor*** Will., Zentralbl. Bakteriol. Hyg., 2 Abt. 48:39. 1918. =?Blastomycete.

120. ***T. (Hormiscium) correae*** Rabenh., in Klotzschii Herb. Vivum Mycol. Fung. ed. I,Cent. 28, No. 1771. Anno 1853; Bot. Zeitung (Berlin) 11:238. 1853. Nom.inval. Art. 32.1. ICBN. Attributed to de Bary in Saccardo, Syll. Fung. 4:263.1886; and Lindau, Rabenh. Krypt.-Fl. 2 ed., 1, VIII Abt.:586. 1907 **Lectotype designated herein**: (B!). Isolectotypes: (K!, NY!, L 910,252-585!, L 910,252-596!, PR 777215!). Material contains clumps of cells and septate hyphae which are brown and thick-walled.

121. ***T. corsellii*** (Neveu-Lemaire) Vuill., Encycl. Mycol. 2:113. 1931. ≡*Cryptococus corselli* Neveu-Lemaire, Parasitologie des Animaux Domestiques, maladies parasitaires non bacteriennes. J. Lamarre. Paris, p. 60. 1912. =Blastomycete.

122. ***T. corsellii*** (Neveu-Lemaire) Coudert, Guide Pratique de Mycologie Médicale, Paris, p. 272. 1955. Nom. illeg. Art. 52.1. ICBN. ≡*Cryptococcus corsellii* Neveu-Lemaire, Parasitologie des Animaux Domestiques, Maladies parasitaires non bacteriennes, J. Lamarre. Paris, p. 60. 1912. =Blasto mycete.

123. ***T. corticalis*** (Peck) Sacc., Syll. Fung. 4:253. 1886. ≡*Oidium corticale* Peck, Annual Rep. New York State Mus. 27:105. 1875. Holotype: On old bark, North Greenbush [Rensselaer County, New York], C.H. Peck, (NYS!). ≡*Pseudaegerita corticalis* (Peck) J.L. Crane & Schokn., Mycologia 73:79-81. 1981.

124. ***T. crocea*** Mart., Fl. Crypt. Erlang., p. 357. 1817. ≡*Oidium croceum* (Mart.) Link in Willd., Sp. Pl. 6(1):124. 1824. Type: Lost.

125. ***T. cremoris*** Hammer & Cordes, Iowa Agric. Exp. Sta. Res. Bull. 61:12. 1920. =*Candida kefyer* (Beij.) Uden & H.R. Buckley fide Rij, The Yeasts, a Taxonomic Study, ed. 3, p. 721. 1984. Teleomorph: *Kluyveromyces marxianus* (E.C. Hansen) Van der Walt fide Lachance in Kurtzman & Fell, The Yeasts, a Taxonomic Study, ed. 4, p. 236. 1998.

126. ***T. crustacea*** Schw., Syn. Fung. Amer. Bor. , p. 286. 1832. Presumed type: In ramos salicinos Bethl., (PH 2775!, FH!). Possibly *Capnodium salicinum* Mont.

127. ***T. cryptogena*** Opiz, Lotos 5:216. 1855. Type: Lost. Not identifiable from the description.

128. ***T. cucurbitarum*** Schwein., Trans. Amer. Philos. Soc. N.S. 4:286. 1832. **Lectotype designated herein**: In cortice Cucurbitarum, Bethl. scr. Schw. (PH!). Isolectotypes: (BPI!, K!). =*Torula herbarum* (Pers.) Link:Fr.

129. ***T. culmicola*** Corda:Fr., in Sturm's, Deutschl. Flora III (Pilze), Bd. 2, Hefte 8:93. 1829; Fries, Syst. Mycol. 3:502. 1832. Holotype: Auf faulenden Halmen des *Typha latifolia*. Scr. Corda. (PR 155679!). =*Torula herbarum* (Pers.) Link:Fr.

130. ***T. cupulifera*** Berk. & Br., Herbarium name for the reputed anamorph of *Sphaeria cupulifera* Berk. & Br. ≡*Chaetosphaeria cupulifera* (Berk. & Br.) Sacc., Syll. Fung. 2:94. 1883. =*Catenularia cuneiformis* (Richon) Mason, fide Mason, Mycol. Pap. I.M.I. 5:121. 1941.

131. *T.* ***curta*** Corda, Icon. Fung. 6:5. 1854. ≡*Oospora curta* (Corda) Sacc. & Vogl., Syll. Fung. 4:24. 1886. Type: (PR). ≡*Xylohypha curta* (Corda) S. Hughes, Canad. J. Bot. 36:824. 1958. ≡*Xylohyphopsis curta* (Corda) W.A. Baker & Partridge in Partridge, W.A. Baker & Morgan-Jones, Mycotaxon 74:486. 2000.

132. *T.* ***curvata*** Peck, Annual Rep. New York State Mus. 30:53. 1878. ≡*Hormiscium curvatum* (Peck) Sacc., Syll. Fung. 4:265. 1886. Holotype: On dead branches of *Myrica gale*, Adirondack Mountains, N.Y., August. (NYS!). ≡*Taeniolella curvata* (Peck) S. Hughes, Canad. J. Bot. 36:817. 1958.

133. *T.* ***cyanescens*** Kalchbr., Mat. Természettud. Közlem. 3:296. 1865; Hedwigia 4:120. 1865. ≡*Oospora cyanescens* (Kalchbr.) Sacc. & Vogl., Syll. Fung. 4:25. 1886. Type: Hungary, Szepes Hebrich adjoining Szepes Olaszi Forest, on '*Usnea barbata* var. *dasypoga*', Leg. K. Kalchbrenner. Not located. Not identifiable from the description, fide Hawksworth, Persoonia 9:193. 1977. See Hawksworth, Bull. Brit. Mus. Nat. Hist., Bot. 6(3):286. 1979.

134. *T.* ***cylindrica*** Berk., in W.J. Hooker, The English Flora 5(Pt. 2):359. 1836. Type:Not located. Authentic material at (K!), sub *Torula cylindrica* and labeled *Torula expansa* Carmichael =*Dendryphion nanum* (Nees) S. Hughes.

135. *T.* ***cyperina*** Roum. & Pat., Fungi Gall. Exs. Cent. 34, No. 3389. Anno 1885; Rev. Mycol. 7:176-177. 1885. **Lectotype designated herein**: Sur les feuilles sèches du *Cyperus longus* L., Environ de Toulouse, Hiver 1885. C. Roumeguère, Fung. Gall. Exs. No. 3389. (ILL!), Isolectotype: (K!). =*Rutola graminis* (Desm.) J.L. Crane & Schokn.

136. *T.* ***darwinii*** Speg., Bol. Acad. Nac. Ci. 11(2):303. (1877) 1888. Holotype: Ad *Cyttariam darwinii* putrescentem ac dejectam in sylvia prope Penguin rookery in Staten Island, Feb. 1882, Leg. C.L. Spegazzini (LPS 12754!). =A Coelomycete.

137. *T.* ***dattila*** Kluyver, Biochemische Siukerbepalingen, Diss. Delft. Leiden., p. 14. 1914. Original strain investigated by Kluyver in 1914. (CBS 137). ≡*Mycotorula dattila* (Kluyver) F.C. Harrison, Trans. R. Soc. Can. Ser. 3, 22(Pt.1, Sec. 5):219-220. 1928. ≡*Torulopsis dattila* (Kluyver) Lodder, fide J. Lodder,Verh. Kon. Ned. Akad. Wetensch. Amsterdam Afd. Natuurk., Sec. 2, 32:139. 1934. ≡*Cryptococcus dattilus* (Kluyver) C.E. Skinner, Amer. Midl. Naturalist 43:248. 1950. Teleomorph: *Kluyveromyces thermolerans* (Filippov) Yarrow fide Rij, The Yeasts, a Taxonomic Study, ed. 3, p. 247. 1984.

138. *T.* ***decolans*** Okunuki, Jap. J. Bot. 5:320. 1931. Original strain investigated by Okunuki at (CBS). =*Rhodotorula mucilaginosa* (A. Jörg.) F.C. Harrison, fide Fell & Statzell-Tallman in Kurtzman & Fell, The Yeasts, a Taxonomic Study, ed. 4, p. 820. 1998.

139. *T.* ***dematia*** Berkhout, De Schimmelgeslachten *Monilia, Oidium, Oospora,* en *Torula*, p. 45. 1923. Nom. nud. Art. 32.1. ICBN. =*Moniliella suaveolens* (Linder) Arx, fide Rao & de Hoog, Persoonia 8:202. 1975. Based on strains CBS 314.31, CBS 381.36, and CBS 382.36.

140. *T.* ***dendroides*** Peyronel, I. Germi Atmosferici dei Funghi con Micelio. Disser. Univ. Padova, p. 19. 1913. Type: Not located.

141. *T.* ***densa*** P. Karst. & Har., J. Bot. (Morot) 4:362. 1890. Holotype: Ad *Cereum alatum*. Paramaribo Guyanae batavae (Kegel No. 597). Herbarium P.A.

Karsten No. 1099. (H!). Isotype: (PC!). Based on a Coelomycete stroma. cf. *Dothidea*.

142. ***T. deospora*** (Batista & H.P. Upadhyay) de Hoog, Trans. Brit. Mycol. Soc. 64:343. 1975. ≡*Trichocladium deosporum* Batista & H.P. Upadhyay, Atas Inst. Micol. Univ. Recife 2:326. 1965. Holotype: Ad terram, Parnamirim, Natal, Rio Grande do Norte, Brasiliae, Leg. J. Oliverira da Silva, 8.11.1964. (URM 1983!).
143. ***T. dichroa*** Sacc., Nuovo Giorn. Bot. Ital. 23:213. 1916. Holotype: On *Saccharum spontaneum*, Los Banos, Philippines, Leg. C.F. Baker, 3737, Nov. 1914. (PAD!). =*Arthrinium arundinis* (Corda) Dyko & B.C. Sutton.
144. ***T. dicoccum*** (Auersw.) P. Joly, Bull. Soc. Mycol. France 80:193. 1964. ≡*Bispora dicoccum* Auersw., Klotzschii Herb.Vivum Mycol.Fung. ed. 1, Anno1851. **Lectotype designated herein**: No. 1688. (UPS!).=*Rutola graminis* (Desm.:Fries) J.L. Crane & Schokn.
145. ***T. diffluens*** Zach in Wolfram & Zach, An erroneous citation in Just's Bot. Jahresber., 63(Abt. 2):1039. 1944 for *Torulopsis diffluens* Zach in Wolfram & Zach., Arch. Klin. Exp. Dermatol. 171:690. 1934. =*Cryptococcus albidus* (Saito) C.E. Skinner fide Fell & Statzell-Tallman in Kurtzman & Fell, The Yeasts, a Taxonomic Study, ed. 4, p. 748. 1998.
146. ***T. dimidiata*** Penz., Michelia 2:466. 1882. Type: Not located. =*Hendersonula toruloidea* Nattrass synanamorph *Scytalidium*, fide M.B. Ellis, More Dematiaceous Hyphomycetes, p. 16. 1976.
147. ***T. disciformis*** Corda, Icon. Fung. 1:8. 1837. ≡*Hormiscium disciforme* (Corda) Bonord., Handb. Allg. Myk., p. 34. 1851. Type: Not located.
148. ***T. dissiliens*** Duby, Mém. Soc. Phys. Hist. Nat. Genève 7:215. 1836. ≡*Septocylindrium dissiliens* (Duby) Sacc., Myco. Ven. Cent. 6, No. 583. Anno 1876; Michelia 1:89. 1877. Authentic material: On *Vitis vinifera* L. ex herb. J.E. Duby. (STR!, K!). G.L. Rabenhorst-H.G. Winter, ed. 3, Fungi Eur. Exs., Klotschii Herb. Vivum Mycol. Fung.,Cent. 29, No. 2878. Anno 1883. ≡*Phaeoramularia dissiliens* (Duby) Deighton, in M.B. Ellis, More Dematiaceous Hyphomycetes, p. 324. 1976.
149. ***T. dissita*** Berk. & M.A. Curtis, in Berk., Grevillea 3:14. 1874. Holotype: Inside of oak log, Society Hill, S.C., March 1857. No. 3696. (K!). Isotypes: (FH!, NY!, NYS!). =*Bispora betulina* (Corda) S. Hughes.
150. ***T. diversa*** Cooke, Grevillea 7:33. 1878. Holotype: On *Agave americana* L., Darien, Georgia, U.S.A., M.C. Cooke No. 2522. (K!). ≡*Sirodesmium diversum* (Cooke) S. Hughes, Naturalist (London) 1952:97. 1952. ≡*Coniosporium diversum* (Cooke) J.L. Crane & Schokn., Mycologia, 69:534. 1977.
151. ***T. donacina*** Thüm., Myc. Univ. Cent. No. 887. Anno 1877. **Lectotype designated herein**: Graecia, Athen in *Conacis arundinaceae* Beauv. culmi emortius. Vere 1877. Leg. T. von Heldreich, Myc. Univ. No. 887. (ILL!). Isolectotypes: (NY!, L 910-254, 723!). =*Arthrinium arundinis* (Corda) Dyko & B.C. Sutton.

152 ***T. donacis*** Henn., Hedwigia 48:115. 1908. Holotype: Para [Brazil] Hort. Botan. Goeldi in vaginis siccis *Arundinis donacis*, Febr. 1908, Baker n. 269. (B!). Isotype: (K!). =*Torula herbarum* (Pers.) Link:Fr.

153. ***T. dubia*** F.C. Harrison, Proc. & Trans. Roy. Soc. Canada, Ser. 3, 21(Pt. 2, Sec. 5):353. 1927. =Blastomycete.

154. ***T. duclauxii*** Heinze & Cohn, Z. Hyg. Infektionskrankh. 46:294. 1904. [As *duclaux*]. =Blastomycete.

155. ***T. duclauxii*** F.C. Harrison, Proc. & Trans. Roy. Soc. Canada, Ser. 3, 32(Pt. 2, Sec. 5):350. 1927. Nom. illeg. Art. 53.1. ICBN. =Blastomycete.

156. ***T. dulcis*** F.C. Harrison, Proc. & Trans. Roy. Soc. Canada, Ser. 3, 21(Pt. 2, Sec. 5):368. 1927. =Blastomycete.

157. ***T. elaeodes*** (Pound & Clem.) S. Hughes, Canad. J. Bot. 36:818. 1958. ≡*Clasterosporium elaeodes* Pound & Clem., Bull. Minn. Geol. & Nat. Hist. Surv. 9:661. 1896. A Nom. Nov. for *C. olivaceum* Ellis & Everh., Proc. Nat. Acad. Philad. 1893:463. 1894. Non (Wallr.) Sacc. (1886). ≡*C. zeae* Sacc. & Syd. in Sacc., Syll. Fung. 14:1083. 1899. ≡*Polyschema olivacea* (Ellis & Everh.) M.B. Ellis, More Dematiaceous Hyphomycetes, p. 372. 1976.

158. ***T. elasticae*** (Koord.) Sacc. & Trotter, Syll. Fung. 22:1341. 1913. ≡*Catenularia elasticae* Koord., Verh. Kon. Ned. Akad. Wetensch., Afd. Natuurk., Tweede Section 13(4):230. 1907. Holotype: Auf faulenden Blattern von *Ficus elasticae* Robx. in Provinz Kedw, Java,. S.H. Koorders, Marz 1907. (B!). ≡*Sagrahamala elasticae* (Koord.) Subram., Kavaka, 5:98. 1977. ≡*Gliomastix elasticae* (Koord.) J.L. Crane & Schokn., Mycologia 69:537. 1977.

159.***T. ellipsoidea*** Nokolajewa, Izv. Imp. S.-Peterburgsk. Bot. Sada 7:129-131. 1907. =Blastomycete.

160. ***T. ellipsospora*** Corda, Icon. Fung. 1:8. 1837. Type: In ligno pini prope Reichenberg. (PR). ≡*Oospora ellipsospora* (Corda) Sacc. & Voglino, Syll. Fung. 4:24. 1886. =*Xylohypha ferruginosa* (Corda) S. Hughes, Canad. J. Bot. 36:824. 1958.

161. ***T. ellisii*** Yadav & Lal, in Lal & Yadav, J. Indian Bot. Soc. 44:404. 1966. Holotype: On *Sorghum*, Patna, India. Leg. S.P. Lal, 2. ii. 1963. (IMI 100038!). Redescribed and illustrated by M.B. Ellis, More Dematiaceous Hyphomycetes, p. 352. 1976. Probably a *Bispora*.

162. ***T. encausta*** Rabenh., Flora 33:632. 1850. Type: Not located. Not identifiable from description.

163. ***T. epilobii*** Corda, Icon. Fung. 4:23. 1840. Type: Not located. ≡*Oospora epilobii* (Corda) Sacc. & Voglino, Syll. Fung. 4:12. 1886.

164. ***T. epilobii*** Corda forma ***epilobii-rosei*** Thüm., Myc. Univ., Cent.3, No. 290. Anno 1875. Nom. nud. Art. 32.1. ICBN. Material Examined: Bavaria: Bayreuth in *Epilobio roseo*, Leg. Thümen, Aug. 1874. Myc. Univ. No. 290. (B!, ILL!, L!, NY!). Material from L 910,254-713 contains *Sphaerotheca epilobii* (Link:Fr.) de Bary.

165. ***T. epimyces*** Corda, Icon. Fung. 1:8. 1837. Holotype: (PR 155682!). ≡*Oospora epimyces* (Corda) Sacc. & Voglino, Syll. Fung. 4:16-17. 1886. The type material contains *Nectria episphaeria* (Tode:Fr.) Fr. From the illustration and diagnoses, this species is unidentifiable! Corda illustrated conidia in chains.

166. ***T. epistromata*** Cif., Sydowia 10(1-6):176. (1956) 1957. **Lectotype designated herein**: On *Phyllachora guazumae* Henn. on *Guazuma ulmifolia* Lam., Republica Dominicana, Valle del Ciboa, Prov. Santiago, Hoto del Yaque, II.

1930, Leg. R. Ciferri, Mycoflora Domingensis Exsicata No. 370. (M!). Isolectotypes: (DAOM!, ILL!). =*Verticillium lecanii* (D.O. Zimmermann) Viégas, fide W. Gams, *Cephalosporium*-artige Schimmelpilze (Hyphomycetes), p. 177. 1971. Material at ILL contained *Periconia byssoides* Pers.:Fr.

167. ***T. epizoa*** Corda, in Sturm's, Deutschl. Flora III (Pilze), Bd. 2, Hefte 8:97. 1819. Holotype: (PR 502756!). ≡*Sporendonema epizoum* (Corda:Fr.) Cif. & Redaelli, Atti. Ist. Bot "Giovanni Briosi" Ser. 4, 5:185. 1934; J. Trop. Med. Hyg. 37:169-170. 1934. =*Wallemia sebi* (Fr.:Fr.) Arx.
168. ***T. epizoa*** Corda var. ***muriae*** J. Kickx f., Mem. Acad. Roy. Sci. Lett. Brussels 20:44. 1847. Type: Not located. =*Sporendonema epizoum* (Corda) Cif. & Redaelli, Atti. Ist. Bot. 'Giovanni Briosi" Ser. 4, 5:186. 1934. =*Wallemia sebi* (Fr.:Fr.) Arx.
169. ***T. equina*** Desm., Ann. Sci. Nat. Bot. Ser. 4, 4:126-127. 1855. Neotype: H.G. 1510. (PC!). ≡*Oospora equina* (Desm.) Sacc. & Voglino, Syll. Fung. 4:22. 1886. ≡*Sphaerosporium equinum* (Desm.) J.L. Crane & Schokn., Mycologia 78:86. 1986.
170. ***T. eriophori*** Berk. in Smith's English Flora 5(2):359. 1836. Type: Not located. =*Arthrinium sporophleum* Kunze:Fr., fide M.B. Ellis, Mycol. Pap. I.M.I. 103:26. 1965.
171. ***T. erumpens*** Ellis & Everh., Amer. Naturalist, 31:430. 1897. Holotype: On decorticated, weather-beaten wood (poplar), Morrison, Colo., Dec. 31, 1896. E. Bethel No. 166. (NY!). =*Trimmatostroma salicis* Corda, fide Sutton., Mycol. Pap. I.M.I. 132:123. 1973.
172. ***T. erysiphoides*** (Fr.:Fr.) Nyl., in Nyl. & A.T. Saelan, Herb. Mus. Fenn., p. 107. 1859. ≡*Oidium erysiphoides* Fr.:Fr., Syst. Mycol. 3:432. 1832. Authentic material: In foliis Cucumarum. Aestate. Ex Herb. Fr., Klotzch, Herb. vivum myc. Fung. ed. I, Cent. 2, No. 184. Anno 1832. (UPS!). Not identifi able.
173. ***T. exitiosa*** De Seynes, Compt. Rend. Assoc. Franc. Avancem. Sci. 8:730-733. 1880. Type: Not located. Not identifiable from the description. See Sacc., Michelia 2:554. 1882.
174. ***T. expansa*** (Kunze) Pers.:Fr., Mycol. Eur. 1:22. 1822; Syst. Mycol. 3:501. 1832. ≡*Hormiscium expansum* Kunze, in Kunze & J.C. Schmidt, Mykol. Hefte 1:13. 1817. **Lectotype designated herein**: As *Hormiscium expansum* m, Herb. C.H. Persoon scripsit G. Kunze. (L 910,267-941!). Isolectotype: (B!). =*Torula herbarum* (Pers.) Link:Fr., fide Hughes, Canad. J. Bot. 36:818. 1958.
175. ***T. expansa*** (Kunze) Pers.:Fr. forma ***caulium*** Roum., Fungi Gall. Exs., Cent. 26, No. 2541. Anno 1883. Nom. Inval. Art. 32.1. ICBN. Syntypes examined: Sur les tiges séchés de l'*Urtica dioica* L., November 1882. Chailly (Seine-et-Marne). Feuilleaubois. (ILL!, L 910,252-586!). Type contains empty fruiting bodies.
176. ***T. expansa*** (Kunze) Pers.:Fr. var. ***telae*** Sacc., Syll. Fung. 4:256. 1886. **Lectotype designated herein**: Sur une toile commune exposée à la pluie et pouressante. Toulouse, Hiver 1878. Leg. D.O. Zimmermann & C.

Roumeguère, in Roum., Fungi Gall. Exs., Cent. 4, No. 314. Anno1879. (ILL!). =*Dendryphion nanum* (Nees:Fr.) S. Hughes.

177. ***T. faginea*** Fuckel, Hedwigia 5:30. 1866. **Lectotype designated herein**: Ad fagi corticem adhuc vivum, ca. Weinheim ad viam montanam, L. Fuckel, Fungi Rhen. Exs. Suppl., Fasc. 2, No. 1620. Anno 1866.(G!). Isolectotypes: (FH!, L!). ≡*Taeniolella faginea* (Fuckel) S. Hughes, Canad. J. Bot. 36:817. 1958.
178. ***T. farinacea*** Preuss, in Sturm's, Deutschl. Flora III (Pilze), Bd. 6:11. 1848; Linnaea. 25:73. 1852. ≡*Oospora farinacea* (Preuss) Sacc. & Voglino, Syll. Fung. 4:14. 1886. Holotype: Auf Kiefernnadeln (Beschreibung auf *Juglans*-Holz). (B). Probably *Chrysosporium* sp., fide W. Gams, *Cephalosporium*-artige Schimmelpilze (Hyphomycetes), p. 209. 1971.
179. ***T. fasciculata*** Penz., Michelia 2:466. 1882. Type: Not located. Not identifiable from the description.
180. ***T. fasciculata*** Matsush., Icon. Microfung., pp. 153-154. 1975. Nom. illeg. Art. 53.1. ICBN. Holotype: In folio mortuo *Cinnamomi japonici*, Hachijo Island, Tokyo, Japan, September 1970, Leg. T. Matsushima 2503. (T. Matsushima Herb.!). ≡*Matsushimaea fasciculata* Matsush. ex Subraman., Kavaka, 5:96-97. (1977) 1978.
181. ***T. fenestralis*** (Roth) Schwabe, Linnaea 15:279-282. 1841. ≡*Conferva fenestralis* Roth, Tent. Fl. Germ. 3:495. 1800. ≡*Byssocladium fenestrale* (Roth) Link, Ges. Naturf. Freunde Berlin Mag. 2:36. 1816. ≡*Sporotrichum fenestrale* (Roth) Ditmar, in Sturm's, Deutschl. Flora III (Pilze), Bd. 1, Hefte 4:1. 1817. Type:Destroyed. Based on mycelium fide Fries, Syst. Mycol. 3 (Index):66. 1832.
182. ***T. fermentati*** Saito, Jap. J. Bot. 1:41. 1922. =*Candida guilliermondii* (Castagne) Langeron & Guerra, fide Lodder, The Yeasts, a Taxonomic Study, ed. 2, p. 968. 1970. Teleomorph: *Torulaspora fermentati* (Saito) Novák & Zsolt, Acta Bot. Acad. Sci. Hung. 7:113. 1961. Nom. Inval. Art. 33.3. ICBN. =*Pichia guilliermondii* Wickerham. See Kurtzman in Kurtzman & Fell, The Yeasts, a Taxonomic Study, ed. 4, p. 308. 1998.
183. ***T. ferruginea*** (Schwein.) Spreng., Linn. Syst. Veg. Ed. 16, 4(1):556. 1827. =*Conoplea ferruginea* Schwein.:Fr., Schriften Naturf. Ges. Leipzig 1:77. 1822; Syst. Mycol. 3(Index):77. 1832. Type: Lost. Not identifiable from description. See Hughes, Canad. J. Bot. 38:667. 1960.
184. ***T. ferruginosa*** Corda, in Sturm's, Deutschl. Flora III (Pilze), Bd. 2, Hefte 8:89. 1829. Nom. illeg. Art. 53.1. ICBN. Type: (PR). =*Xylohypha ferruginosa* (Corda) S. Hughes, Canad. J. Bot. 36:824. 1958.
185. ***T. flagellum*** Riess, Bot. Zeitung (Berlin & Leipzig) 11:140. 1853. ≡*Oospora flagellum* (Riess) Sacc., Syll. Fung. 4:12. 1886. Type: Not preserved. Not identifiable from the description. Spores oval, with a short point at each end, 5 to 6µ long, fide W. Gams, *Cephalosporium*-artige Schimmelpilze (Hyphomycetes), p. 209. 1971.
186. ***T. flava*** Saito, Jap. J. Bot. 1:45. 1922. Authentic culture from Saito, dated Sept. 1923, preserved as CBS 331. ≡*Chromotorula flava* (Saito) F.C. Harrison, Trans. Roy. Soc. Can. Ser. 3, 22(Pt. 2, Sec. 5):201. 1928. ≡*Rhodotorula flava*

(Saito) Lodder, Verh. Kon. Akad. Wetensch. Amsterdam. Verh. Afd. Natuurk. Sec. 2, Vol. 32:83. 1934. ≡*Rhodotorula tokyoensis* Tak. Kobay. ex Hasegawa var. *flava* (Saito) Hasegawa, J. Ferment. Technol. (Japan) 36:200, 201. 1958. Nom. Inval. Art. 33.3. ICBN. ≡*Cryptococcus flavus* (Saito) Phaff & Fell., in J. Lodder, The Yeasts, a Taxonomic Study, ed. 2, p. 1107. 1970.

187. ***T. flavescens*** Saito, Jap. J. Bot. 1:43. 1922. Investigated culture preserved as CBS 9421. ≡*Torulopsis flavescens* (Saito) Lodder, Verh. Kon. Ned. Akad. Wetensch., Afd. Natuurk., Sec. 2, 32:166. 1934. ≡*Cryptococcus flavescens* (Saito) C.E. Skinner, Amer. Midl. Naturalist 43:249. 1950. ≡*Cryptococcus laurentii* (Kufferath) C.E. Skinner var. *flavescens* (Saito) Lodder & Kreger fide J. Lodder & Kreger-van Rij, The Yeasts, a Taxonomic Study, ed. 1, p. 381. 1952. ≡*Cryptococcus laurantii* (Kuff.) C.E. Skinner var. *flavescens* (Saito) Coudert, Guide Pratique de Mycologie Médicale, p. 244. 1955. Nom. illegit Art. 53.1. ICBN.

188. ***T. friata*** Preuss, Linnaea 25:73. 1852. Type: (B). Not available for examination. ≡*Oospora friata* (Preuss) Sacc. & Voglino, Syll. Fung. 4:18. 1886. =*Chrysosporium* sp. with strongly warted conidia, 4-5.5 x 2.5-3.5 µm, fide W.Gams, *Cephalosporium*-artige Schimmelpilze (Hyphomycetes), p. 209. 1971.

189. ***T. fructigena*** Pers., Ann. Bot. (Usteri) 15 (=Neue Ann. Bot. 9):26. 1795. Authentic material: (L 910,267-940!). ≡*Monilia fructigena* (Pers.) Pers., Syn. Meth. Fung., p. 693. 1801. ≡*Oidium fructigenum* (Persoon) J.C. Schmidt:Fr. in Kunze & J.C. Schmidt, Mykol. Hefte 1:80. 1817; Syst. Mycol. 3:430. 1832. ≡*Acrosporium* (*Oidium*) *fructigenum* (Pers.) Pers., Mycol. Eur., 1:24. 1822. ≡*Oospora fructigena* (Pers.) Wallr.:Fr., Fl. Crypt. Germ. 2:182. 1833.

190. ***T. fuckelii*** Sacc., Syll. Fung. 4:250. 1886. ≡*Torula velutina* Fuckel, Symb. Mycol., p. 338. 1870. Non *Torula velutina* Preuss, 1852. ?=*Melanconium atrum* Link. fide Hughes, Canad. J. Bot. 36:819. 1958.

191. ***T. fuliginea*** (Saito) Berkout, De Schimmelgeslachten *Monilia*, *Oidium*, *Oospora*, en *Torula* Dissertation Utrecht., p. 53. 1923. Type: Not located. ≡*Catenularia fuliginea* Saito, Jour. Sci. Coll. Imp. Univ. Tokyo 18(5):51. 1904. =*Sporendonema epizoum* (Corda) Cif. & Redaelli, Atti. Ist. Bot. "Giovanni Briosi", Ser. 4, 5:186. 1934. =*Wallemia sebi* (Fr.:Fr.) Arx.

192. ***T. fuliginosa*** Pers. in Moug. & Nestl., Stirpes Cryptogamae Vogeso-Rhenanae Quas in Rheni Superioris Ingeriorisque, Nec Non Vogesorum Praefectieris, Collegerunt, Fasc. 6, No. 589. 1818. (FH!, L 910,249-1402!). Lectotypified by the lectotype of *Antennaria pinophila* Nees:Fr. A superfluous change of epithet, fide Hughes, New Zealand J. Bot. 8:178. 1970. ≡*Antennatula pinophila* (Nees:Fr.) F. Strauss.

193. ***T. fuliginosa*** (Wallr.) Sacc., Syll. Fung. 4:248. 1886. ≡*Oospora fuliginosa* Wallr., Fl. Crypt. Germ. 2:184. 1833. Type: Ad corticem *Fraxini* putridum, Thüringen. Leg. Wallroth. (STR). =*Xylohypha nigrescens* (Pers.:Fr.) Mason, fide Hughes, Canad. J. Bot. 36:825. 1958.

194. ***T. fuliginosa*** Pers. var. ***ericophila*** (Link) Pers., Mycol. Eur. 1:22. 1822. ≡*Sphaeria ericophila* Link, Schrad. Neues J. Bot. 3:17. 1809. ≡*Antennaria*

ericophila (Link) Nees, Syst. Pilze, p. 279. 1816. ≡*Antennaria ericophila* (Link) Link:Fr. in Willd. Sp. Pl. 6(1):118. 1824. Syst. Mycol. 3(1)230. 1829. ≡*Antennularia ericophila* (Link:Fr.) Höhn., Akad. Wiss. Math.-Naturwiss. Kl.Abt. 1, 118:1198. 1909. For full synonomy and typification see Hughes, New Zealand J. Bot. 8:156. 1970.

195. ***T. fuliginosa*** Pers. var. ***pinophila*** (Nees) Pers., Mycol. Eur. 1:22. 1822. ≡*Antennaria pinophila* Nees:Fr., Syst. Pilze, p. 279. 1816; Syst. Mycol. 3(1):231. 1829. ≡*Antennatula pinophila* (Nees:Fries) F. Strauss, Flora (Beilage)33:99. 1850. Authentic material examined: (L 910,267,930!). For full lectotypification and synonomy see Hughes, New Zealand J. Bot. 8:178.1970.

196. ***T. fulva*** (Kunze) Corda, in Sturm's, Deutschl. Flora III (Pilze), Bd. 2, Hefte 8:81. 1829. ≡*Alysidium fulvum* Kunze in Kunze & J.C. Schmidt, Mycol. Hefte 1:12. 1817. Type: (L). ≡*Oidium fulvum* (Kunze) Link:Fr. in Willd., Sp. Pl. IV,6(1):121. 1824; Syst. Mycol. 3:430. 1832. ≡*Acrosporium fulvum* (Kunze)Pers., Mycol. Eur. 1:24. 1822. ≡*Oospora fulva* (Kunze:Fr.) Sacc. & Voglino,Syll. Fung 4:22. 1886. =*Alysidium dubium* (Pers.:Fr.) M.B. Ellis, More Dematiaceous Hyphomycetes, p. 89. 1971.

197. ***T. fulva*** Opiz, Lotos 5:216. 1855. Nom. illeg. Art. 53.1. ICBN. Type: Einen braunen Filz unter der Epidermis des Stengels von *Lappa* bilden. Folimanka, 11 Nov. 1854. Leg. Schobel. Not located. An authentic specimen from Praha-Folimanka, dated 29 Oct. 1854. Leg. Schobel, PR 704572! contains the conidia of *Torula herbarum* (Pers.) Link:Fr.

198. ***T. ?fumaginea*** Speg., Anales Mus. Nac. Hist. Nat. Buenos Aires Ser. 3, 20:431. 1910. Holotype: Ad folia viva *Zuccagniae punctatae* in aridis, Cacheuta, prope Mendoza, Febr. 1909 (LPS 12751!). ≡*Torulopsis fumaginea* (Speg.) Speg., Physis (Buenos Aires) 4(17):293. 1918. ≡*Torulopsiella fumaginea* (Speg.) Bender, Mycologia 24:411. 1932.

199. ***T. fumago*** Chevall., Flore Gén. Env. Paris 1:34: 1826. ≡*Fumago vagans* Pers., Mycol. Eur. 1:9. 1822. Authentic material: (L 910,267-925!). The name is based on a mixture of *Aureobasidium pullulans* (de Bary) Arnaud and *Cladosporium herbarum* (Pers.) Link:Fr. For a discussion see Hughes, Mycologia 68:773-774. 1976.

200. ***T. funerea*** Ces. in Rabenh. Klotzschii, Herb. Vivum Myc.Fung., ed. 2, Cent. I, No. 79. Anno 1855. **Lectotype designated herein**: In culmis *Jucorum arescentibus* sistit, Vercellis, Oct. 1853. Cesati, Klotzsch Herb. Vivum Myc. No. 79. (BM!). Isolectotypes: (B!, FH!, K!, L 910,252-597!, PR 777236!). ≡*Periconia funerea* (Ces.) Mason & M.B. Ellis, Mycol. Pap. I.M.I. 56:117. 1953.

201. ***T. fusca*** (Bonord.) Sacc., Syll. Fung. 4:260. 1886. ≡*Alysidium fuscum* Bonord., Handb. Myk., p. 35. 185l. ≡*Oospora fusca* (Bonord.) Grove, J. Bot. 23:163-164.1885. Type: Not located. Material at (G!) labeled: Auf faulen Holz von *Corylus avellana* in Reingan ex herb L. Fuckel. =*Xylohypha ferruginosa* (Corda) S. Hughes. Material at (B) labeled *Torula fusca* n. sp. by Nees. =*X. ferruginosa*.

202. ***T. fusidioides*** Corda, Icon. Fung. 2:9. 1838. [as *T. Ch. fusidioides*]. Holotype: PR 155685!. ≡*Chalara fusidioides* (Corda) Rabenh., fide Hughes, Canad. J. Bot. 36:747. 1958.
203. ***T. fusidium*** Thüm., Flora, 60:412. 1877. **Lectotype designated herein**: In monte 'Boschberg' pr. Somerset-East ad folia viva *Encephalarti cycadifolii* Lehm. 1876. (Nr. 1238). Leg. Prof. P. MacOwan (L 910,215-2782!). Isolectotypes: (ILL!, NY!). ≡*Oospora fusidium* (Thüm.) Sacc. & Voglino, Syll. Fung. 4:21. 1886. Type contains small, globose cells, 1.5-2.0 µm in diameter, in short chains or in clumps. Not identifiable, fide W. Gams, *Cepha losporium*-artige Schimmelpilze (Hyphomycetes), p. 210. 1971.
204. ***T. fusigona*** Moug. in Fr.:Fr., Syst. Mycol. 3:500. 1832. Type: Not located. Authentic material at (K!) is dated 1844. =*Xylohypha nigrescens* (Pers.:Fr.) Mason.
205. ***T. fusoidea*** Cooke & H.W. Harkn., Grevillea 12:28. 1883. Holotype: On *Gynerium argenteum* (H.W. Harkness No. 2136). California. (K!). =*Myrothecium atrum* (J. Desmazières) M.C. Tulloch.
206. ***T. galleti*** Roum., Rev. Mycol., (Toulouse) 5:227. 1883; Fungi Sel. Gall. Exs., Cent. 27, No. 2626 [erroneously printed as No. 1626]. Anno 1883. **Lectotype designated herein**: Sur les tiges et principalement à la game des feuilles de *l'Angraecum fragrans* Thou. rapporté de l'ile Bourbon, (Eure-et Loire), Leg. Frère Zétiques, Oct. 1882, Comm. Gallet et Feuilleaubois No. 402. (FH!). Isolectotypes: (ILL!, L 910,254-703!, NY!). Based on the hyphae of a sooty mold. The fungus is an undescribed species of *Antennatula* Fries, fide Hughes, Mycologia 68:772. 1976.
207. ***T. gelatinosa*** H. Will, Centralbl. Bakteriol., 2 Abt., 46:256. 1916. =Blastomycete.
208. ***T. gelatinosa*** Saito, Jap. J. Bot. 1:42. 1922. Nom. illeg. Art. 53.1. ICBN. Authentic culture at CBS. ≡*Rhodotorula gelatinosa* Saito ex T. Hasegawa, I. Banno& Yamauchi, J. Gen. Appl. Microbiol. 6:211. 1960. =*Cryptocococus albidus*(Saito) C.E. Skinner var. *albidus*, fide Lodder, The Yeasts, a Taxo nomic Study, ed. 2, p. 1095. 1970. =*Cryptocococus albidus* (Saito) C.E. Skinner fide Kurtzmam & Fell, The Yeasts, aTaxonomic Study, ed. 4, p. 748. 1998.
209. ***T. geotricha*** (Link) Corda, in Sturm's, Deutschl. Flora III (Pilze), Bd. 2, Hefte 8:73. 1829. ≡*Geotrichum candidum* Link, Mag. Naturf. Freunde, Berlin 9:17. 1809. ≡*Botrytis geotricha* (Link) Link in Willd. Sp. P. 6(1):53. 1824. ≡*Acrosporium candidum* (Link) Spreng, Linn. Syst. Veg., ed. 16, 4:556. 1827. Teleomorph: *Galactomyces geotrichum* (E.E. Butler & L.J. Petersen) Redhead & Malloch. See de Hoog, M.T. Smith & E. Guého, Stud. Mycol. 26:81. 1986.
210. ***T. glauca*** Preuss, in Sturm's, Deutschl. Flora III (Pilze), Bd. 6:63. 1851; Linnaea. 24:105. 1851. Type: Herb. Preuss (B). ≡*Oospora glauca* (Preuss) Sacc., Fung. Ital. Pl. 882. 1881; Syll. Fung. 4:25. 1886. Brown, smooth blastospores 7-8 x 3.5-4.0 µm, in chains, fide Gams, *Cephalosporium*-artige Schimmelpilze (Hyphomycetes), p. 210. 1971.
211. ***T. globosa*** H.C. Olson & B.W. Hammer, Iowa State Coll. J. Sci. 10:41. 1935. Nom. inval. Art. 36.1. ICBN. Original strain: NRRL Y-1506. ≡*Torulopsis globosa* (H.C. Olson & B.W. Hammer) Lodder & Kreger, The Yeasts, a

Taxonomic Study, ed. 1, p. 426. 1952. Nom. inval. Art. 36.1. ≡*Candida globosa* Meyer & Yarrow, Int. J. Syst. Bacteriol. 28:614. 1978. Teleomorph: *Citeromyces matritensis* (Santa María) Santa María, fide Lodder, The Yeasts, a Taxonomic Study, ed. 2, p. 123. 1970.

212. ***T. globulifera*** J.X.R. Caspary in Klebs, Abh. Preuss. Geol. Landesanst. N.F. 4(1):12, Pl. 1, Fig. 6. 1907. Fossil fungus.

213. ***T. glomerulosa*** Penz. & Sacc., Malpighia. 15:243. 1901; Icon. Fung. Jav., p. 100. Pl. 68, Fig. 3. 1904. Holotype: In culmis graminum putrescentibus, Tjibodas, (PAD!). =*Lacellinopsis glomerulosa* (Penz. & Sacc.) S. Hughes, Canad. J. Bot. 36:781. 1958.

214. ***T. glutinis*** (Fresen.) E.G. Pringsh. & Bilewlky, Beitr. Biol. Pflanzen 10:131. 1910. ≡*Cryptococcus glutinis* Fresenius, Beitr. Mykol. 2:77-78. 1852. ≡*Saccharomyces glutinis* Cohn, Beitr. Biol. Pflanzen 1(Hefte 2):187. 1872. ≡*Rhodotorula glutinis* (Fresen.) F.C. Harrison, Proc. & Trans. Roy. Soc. Canada, Ser. 3,22(Pt. 1, Sec. 5):190. 1928. ≡*Torulopsis glutinis* (Fresen.) C.W. Dodge, Medical Mycology, p. 351. 1935. ≡*Rhodotorula glutinis* (Fresen.) F.C. Harrison var. *glutinis*, fide Lodder, The Yeasts, a Taxonomic Study, ed. 2, p. 1194. 1970.

215. ***T. glutinosa*** Cooke & H.W. Harkn., Grevillea 9:7. 1880. Holotype: On leaves of *Eriodictyon glutinosum*, Coast Range, California, Autumn 1880, Leg. Harkness No. 1442. (K). Isotype: (BPI!).

216. ***T. gougerotii*** (Matr.) Brumpt, Précis de Parasitologie, ed. 5, p. 1791. 1936. [as *gourerotii*]. ≡*Sporotrichum gougerotii* Matr. , Compt. Rend. Hebd. des Séances Acad. Sci., Paris 150:545. 1910. [as *goureroti*]. ≡*Rhinocladium gougerotii* (Matr.)Verdun, Précis de Parasitologie Humaine, parasites animaux et vegetaux (les bacteries exceptées), Edition 2, p. 677. 1913. ≡*Dematium gougerotii*(Matr.) Grigoraki, Bull. Soc. Mycol. France 40:272-276. 1924. ≡*Oospora gougerotii* (Matr.) Janke, Arch. Dermatol. Syph., Berlin 187:702. 1949. [as *Gougeroti*]. ≡*Phialophora gougerotii* (Matr.) Borelli, Acta Ci. Venez. 6:81. 1955; Mem. del VI Con. Venez. Cient. Med. 5:2945-2972. 1955, See McGinnis,Mycotaxon 6:368. 1977. ≡*Cladosporium gougerotii* (Matr.) Carrión & Da Silva Lacaz, Arch. Derm. Amer. Med. Ass. 72:532. 1955. =*Exophiala mansonii*(Castell.) de Hoog, Studies in Mycol., Baarn, 15:114. 1977.

217. ***T. gougerotii*** (Matr.) Coudert, Guide Pratique de Mycologie Médicale, Paris, p. 273. 1955. [as *gougeroti*]. Nom. illeg. Art. 52.1. ICBN. Based on *Sporotrichum gougerotii* Matr. =*Exophiala mansonii* (Castell.) de Hoog.

218. ***T. graminicola*** Corda:Fr., in Sturm's, Deutschl. Flora III (Pilze), Bd. 2, Hefte 8:91. 1829; Syst. Mycol. 3:503. 1832. Presumed type collection: (PR 155686!). =*Torula herbarum* (Pers.) Link:Fr.

219. ***T. graminis*** Desm.:Fr., Plantes Cryptogames Du Nord De La France, ed. 1, Fasc. 4, No. 169, Leleux, Lille. 1826; Syst. Mycol. 3:502. 1832. **Lectotype designated herein**: Pl. Crypt. N. Fr. ed. 1, Fasc. 4, No. 169. Sur les feuilles sèches des graminées en Mars et en Avril. Leg. Desmazières (L 910,249-1411!). Isolectotypes: (G!; L 910,249-1397!, L 910,267-926!; NY!). ≡*Rutola graminis* (Desm.:Fr.) J.L. Crane & Schokn., Canad. J. Bot. 55:3015. 1977.

220. ***T. graminum*** Link, falsely so cited in M.C. Cooke, Fungi Brit. Exs., ed. 2, Cent. 7, No. 629. Anno 1879. Nom. inval. Art. 32.1.ICBN. Material examined: On grasses, Forden, (J.E. Vize), M.C.Cooke, F. B. Exs. No. 629. (FH!). Not a *Torula*.
221. ***T. (Trachytora) granulosa*** Bubák & J. Serebrian., Hedwigia 57:343. 1916. Holotype: In caulibus emortius *Urticae dioicae*, VIII. 1911, Leg. J. Serebrianikow. (B!). Isotype: (BPI!). =*Torula herbarum* (Pers.) Link:Fr.
222. ***T. grisea*** Svilv., Zentralbl. Bakteriol., Abt. 2, 103:181. 1941. Type: Not located. From the description, this species appears to be based on terminal and intercalary cells.
223. ***T. gropengiesseri*** F.C. Harrison, Proc. & Trans. Roy. Soc. Cańada Ser. 3, 22(Pt. 1, Sec. 5):204. 1928. ≡*Torulopsis gropengiesseri* (F.C. Harrison) Lodder, Verh. Kon. Ned. Akad. Wetensch., Afd. Natuurk., Tweede Section 32:142. 1934. ≡*Cryptococcus gropengiesseri* (F.C. Harrison) C.E. Skinner, Amer. Midl. Naturalist 43:248. 1950. ≡*Candida gropengiesseri* (F.C. Harrison) S.A. Mey. & Yarrow in Yarrow & S.A. Mey., Int. J. Syst. Bacteriol. 28:612. 1978.
224. ***T. grumulosa*** Lindau, in Rabenh. Krypt.-Fl., Zweite Auflage. Erster Band, 8 Abt., p. 579. 1907. Holotype: Auf Harz von *Picea excelsa* bei Putlitz in Brandenburg, Leg. O. Jaap, 23 Aug. 1904 (B!). Type contains the conidia of a *Cladosporium* and *Cheiromycella microscopica* (P. Karst.) S. Hughes. =*Aureobasidium pullulans* (de Bary) G. Arnaud, fide W.B. Cooke, Mycopathol. Mycol. Appl. 12:2. 1959.
225. ***T. (Tetracolium) gyrosa*** Cooke & Massee, Grevillea 16:10. 1887. Holotype: On rotten pine wood, Kew. (K!). Isotype: (NY!). =*Cheiromycella microscopica* (P. Karst.) S. Hughes.
226. ***T. hakeae*** Thüm., Inst. Revista Scien. Litt., Coimbra (Coimbra Univ. Ist. Coimbra) 28:[unpaginated]. 1881; Contributiones ad Floram Mycologicam Lusitanicam No. 422. 188l. Holotype: In *Hakeae safignae* R. Br. fructibus maturis. Coimbra in Horto Botanico. V.79, No. 463, Leg. A. Möller (B!). Material consists of subhyaline, light brown to dark brown hyphae, older cells are darker brown, moniliform, appears sporodochial. Not a *Torula*.
227. ***T. hammonis*** Ehrenb. Nom. nud. Art. 32.1. ICBN., cited as pro Syn. under *Monilia hammonis* Link in Willd. Sp. P. 6(1):127. 1824. Type: Not located. =*Torula graminis* Desm., fide Fries, Syst. Mycol. 3:502. 1832.
228. ***T. hariotiana*** Gonz. Frag., Bol. Soc. Esp. Hist. Nat. 14:149. 1914. **Lectotype designated herein**: In ramulis putrescentis *Acacia farnessia* prope Hispalis (Seville) loco dicto La Trinidad, Ubi collegit 6. III [1]913. (PC!). Isolectotype: (DAOM 59160!). =*Torula herbarum* (Pers.) Link:Fr.
229. ***T. helminthosporoides*** Roum. & Pat., Rev. Mycol. (Toulouse) 5:11. 1883. Type:Sur l'écorce se détachant a l'hiver du tronc du *Thuja orientalis,* cultivé. Toulouse, Octobre 1882. Leg. A. Roumeguère, Fungi Sel. Gall. Exs. Cent. 24, No. 2340. Anno 1883. (ILL!, L 910,254-709!, NY!). Based on branched, brown, constricted hyphae.
230. ***T. herbarum*** (Pers.) Link:Fr., Mag. Ges. Naturf. Freunde, Berlin (Obs. 2) 7:40. (1815) 1816; Syst. Mycol. 3:501. 1832. ≡*T. monilis* Pers., Ann. Bot. (Usteri) 15 (Neue Ann Bot 9; Observ. Mycol. 1):25. 1795. **Lectotype designated herein**: L 910267-998!. Isolectotypes: (L 910, 267-994!, L 910, 267-

995!, L 910, 267-996!). ≡*Monilia herbarum* Pers., Syn. Meth. Fung., p. 693. 1801.

231. ***T. herbarum*** (Pers.) Link:Fr. var. ***affinis*** Sacc., Malpighia 11:320. 1897. Holotype: Sui colomi e sulle foglie di *Scirpus sylvaticus*, Riva-Valsesia, 5 Marzo, 1891, No. 1126, Carestia. (PAD!). =*Rutola graminis* Desm.:Fr.) J.L. Crane & Schokn.
232. ***T. herbarum*** (Pers.) Link:Fr. forma ***belladonae*** Roum., Fungi Sel. Gall. Exs., Cent. 34, No. 3390. Anno 1885; Rev. Mycol. (Toulouse) 7:177. 1885. **Lectotype designated herein**: Sur les tiges sèches, Forêt de Moulineaux, (Seine Inférieure), Octobre 1884. Leg. Abbé Letendre No. 252, F. G. No. 3390. (ILL!). Isolectotypes: (B!, NY!). =*T. herbarum* (Pers.) Link:Fr.
233. ***T. herbarum*** (Pers.) Link:Fr. var. ***cereicola*** Speg., Bol. Acad. Nac. Ci. 25:112. 1921. Holotype: Hab. Sobre cortenza y espinas podridas de *Cereus quisca* en los alrededores de Santiago, Chile, Otono. 1917. (LPS 12747!). =*T. herbarum* (Pers.) Link:Fr.
234. ***T. herbarum*** (Pers.) Link:Fr. forma ***quaternella*** Sacc., Ann. Mycol. 11:556. 1913. Holotype: Ad caules *Thunbergiae grandiflorae*, Philippines, Manila, XII.1912. Leg. E.D. Merrill No. 8464. (PAD!). =*T. verrucospora* (P.N. Mathur & G.P. Singh) B. Sutton.
235. ***T. herbarum*** (Pers.) Link:Fr. forma ***sambuci*** Roum., Fungi Sel. Gall. Exs., Cent. 12, No. 1132 [as No. 1032]. Anno 1881; Rev. Mycol. (Toulouse) 30:32. 1881. Nom. nud. Art. 32.1. ICBN. **Lectotype designated herein**: Jeunes pousses du Sureau. Jardin botanique de Lyon, Septembre 1879, Leg. J. Therry, F. G. No.1132. (ILL!). =*T. herbarum* (Pers.) Link:Fr.
236. ***T. herbarum*** (Pers.) Link:Fr. forma ***senecionis*** Roum., Fungi Sel.Gall. Exs., Cent. 19, No. 1891. Anno 1882. Nom. nud. Art. 32.1. ICBN. **Lectotype designated herein**: Sur les tiges [séchés] de *Senecio fuchsii* Gmel, et *S. jacobaea* L., environs de Malmédy, Belgique, F. G. No. 1891. (ILL!). Isolectotype: (NY!). =*T. herbarum*(Pers.) Link:Fr.
237. ***T. herbarum*** (Pers.) Link:Fr. forma ***solani-pseudo-capsici*** Roum., Fungi Sel. Gall. Exs., Cent. 11, No. 1041. Anno 1881. Nom. nud. Art. 32.1. ICBN. **Lectotype designated herein**: Environs de Toulouse, Hiver 1879. C. Roumeguère, F. G. No. 1041. (ILL!). Isolectotypes: (L!, NY!). =*T. herbarum* (Pers.) Link:Fr.
238. ***T. herbarum*** (Pers.) Link:Fr. forma ***sorghi*** Roum., Fungi Sel. Gall. Exs., Cent. 61, No. 6090. Anno 1892; Rev. Mycol. (Toulouse) 14:114. 1892. **Lectotype designated herein**: Sur les tiges pourrissantes du *Sorghum vulgare*. Noidan, Janvier 1892, F. Fautrey, F. G. No. 6090. (ILL!). Isolectotypes (K!, NY!). =*T. herbarum* (Pers.) Link:Fr.
239. ***T. heteroderae*** Korab, Ukrain Res. Inst. Sugar Ind. Kiev. 6(16):29-67. 1929. Type: Not located. =*Phialophora malorum* (Kidd & Beaumont) McColloch fide Schol-Schwarz, Persoonia 6(1):75. 1970.
240. ***T. heteroderae*** Jacz., Vestn. Ces. Akad. Zemed. 10(6/7):428. 1934. Nom. illegit. Art. 53.1. ICBN. Type: From cysts of *Heterodera schachtii* in Bohemia. Comm. J. Rozsypal as *T. heterodera*, 1932. (CBS 259.32). Not seen. ≡*Cadophora heteroderae* Jacz. ex J.F.H. Beyma, Zentralbl. Bakteriol. Abt. 2, 96:428-430. 1937. ≡*Phialophora heteroderae* (Jacz. ex J.F.H. Beyma) J.F.H.

See Errata

Beyma, Antonie van Leeuwenhoek 9:61. 1943.

241. ***T. heteromorpha*** Penz. & Sacc., Malpighia 15:244. 1901; Icon. Fung. Jav., p. 100, Tab. 68, Fig. 4. 1904. Holotype: In caulibus majoribus putridis, udis, Tjibodas, 4.III.1897. No. 250. (PAD!).
242. ***T. heteromorpha*** J.X.R. Caspary in Klebs, Abh. Preuss. Geol. Landesanst N.F. 4(1):14, Pl.1, Fig. 10. 1907. Fossil Fungus. Nom. illeg. Art. 64.1. ICBN. Non *T. heteromorpha* Penz. & Sacc., 1901.
243. ***T. heterospora*** G.L. Rabenh., Bot. Zeittung (Berlin) 7:2974. 1849; Klotzschii Herb. Vivum Myc. Fung.., ed. 1, Cent. 13, No. 1268. Anno 1849. **Lectotype designated herein**: Auf todten Birnbaumzweigen. No. 1268. (L 910,254-6878!). Isolectotypes: (M!, PR 777257!). =*Trimmatostroma betulinum* (Corda) S. Hughes.
244. ***T. heterospora*** G.D. Westend., Bull. Acad. Roy. Sci. Belgique Ser. 1, 21 (2):239. 1854. Nom. illeg. Art. 53.1. ICBN. Holotype: Sur des cristaux de crème-de-tartre, Conservés dans un endroit humide. Reçu de Mr. Matthys à Bruges, [Belgium]. (BR!). Isotype: (K!). =*Cladosporium* sp.
245. ***T. heveanensis*** Groen., Meded. Alg. Proefstat. Landb. 11:11. 1921. ≡*Candida heveanensis* (Groen.) Diddens & Lodder, Die Anaskosporogenen Hefen. Zweite Halfte, p. 307. 1942. ≡*Torulopsis heveanensis* (Groen.) Mager & Aschner, J. Bacteriol. 53:289. 1947. =*Cryptococcus laurentii* (Kuff.) C.E. Skinner var. *magnus* Lodder & Kreger, fide Lodder, The Yeasts, a Taxonomic Study, ed. 2, p. 1120. 1970. ≡*Cryptococcus heveanensis* (Groen.) Baptist & Kurtzman, Mycologia 68:1201. (1976) 1977. ≡*Cryptococcus magnus* (Lodder & Kreger) Baptist & Kurtzman var. *heveanensis* (Groen.) Golubev, Mikol. Fitopathol. 15:468. 1981.
246. ***T. hexosa*** F.C. Harrison, Proc. & Trans. Roy. Soc. Canada, Ser. 3, 21(Pt. 2, Sec. 5):365. 1927. =Blastomycete.
247. ***T. hippocrepis*** Sacc., Atti Accad. Sci. Veneto-Trentino-Istriana, Padova 2:226. 1873. Isotypes: In foliis *Crataegi oxyacanthae* in sylva S. Marco agri Tarvisini, socia *Septoria oxycanthae* et in foliis *Mespili germanicae* a Selva. Autumno [Italy] (IMI 28632!, K!). =*Hirudinaria macrospora* Ces., fide S. Hughes, Mycol. Pap. I.M.I. 39:23. 1951.
248. ***T. histolytica*** J.L. Stoddard & Cutler, Studies from the Rockefeller Institute for Medical Research 25:89. 1916; Monograph Rockefeller Institute for Medical Research 6:1. 1916. ≡*Cryptococcus histolyticus* (J.L. Stoddard & Cutler) Castrell., Amer. J. Trop. Med. 8:393. 1928. ≡*Torulopsis histolytica* (J.L. Stoddard & Cutler) Castrell. & Jacomo, J. Trop. Med. Hyg. 36:316. 1933. =*Cryptococcus neoformans* (Sanfelice) Vuill., fide Lodder, The Yeasts, a Taxonomic Study, ed. 2, p. 1132. 1970.
249. ***T. holmii*** A. Jorg., Die Mikroorganismen dev Gärungsindustrie. Berlin, Ed. 5, p. 395. 1909. Type strain: From buttermilk, CBS 135. ≡*Torulopsis holmii* (A. Jorg.) Lodder, Verh. Kon. Ned. Akad. Wetensch., Afd. Natuurk., Tweede Section 32:136. 1934. ≡*Cryptococcus holmii* (A. Jorg.) C.E. Skinner, Amer. Midl. Naturalist 43:248. 1950. ≡*Torulopsis holmii* (A. Jorg.) Coudert, Guide Pratique de Mycologie Médicale, p. 248. 1955. Nom. illeg. Art. 52.1. ICBN. ≡*Candida holmi* (A. Jorg.) Meyer & Yarrow, Int. J. Syst. Bacteriol. 28:612. 1978.

250. ***T. humicola*** Dasz., Bull. Soc. Bot. Genève Ser. 2, 4:289. 1912. ≡*Mycotorula humicola* (Dasz.) F.C. Harrison, Proc. & Trans. Roy. Soc. Canada, Ser. 3, 22(Pt. 1, Sec. 5):217-218. 1928. ≡*Candida humicola* (Dasz.) Diddens & Lodder, Die Anaskosporogen en Hefen Zweite Halfte, p. 266. 1942. ≡*Azymoprocandida humicola* (Dasz.) Novák & Zsolt, Acta Bot. Acad. Sci.Hung. 7:132. 1961. Nom. Inval. Art. 33.3. ICBN. ≡*Apiotrichum humicola* (Dasz.) Arx & Weijman, Antonie van Leeuwenhoek 45:553. 1979. ≡*Vanrija humicola* (Dasz.), R.T. Moore, Bot. Mar. 23:368. 1980. ≡*Cryptococcus humicola* (Dasz.) Golubev, Mikol. Fitopathol. 15:467. 1981. [as *humicolus*].

251. ***T. hyalinula*** Sacc., Michelia 1:265. 1878. **Lectotype designated herein**: In *Capnodio footii* folia *Oleae fragrantis* invadente. In Horto Patavino, Feb. 1877. Mycotheca Veneta No. 1255. Anno 1878. (PAD!). Isolectotype: (NY!). The cylindrical conidia apparently belong to *Acremonium strictum* W. Gams. However, the description and illustration are based on Myc. Ven. No. 574. Anno 1876, which is *A. hyalinulum* fide W. Gams. ≡*Oospora hyalinula* (Sacc.) Sacc., Fung. Ital. Fasc. 17-28, Tab. 878. 1881. ≡*Acremonium hyalinulum* (Sacc.), W. Gams, *Cephalosporium*-artige Schimmelpilze (Hyphomycetes), p. 104. 1971.

252. ***T. hypoxylicola*** Preuss, Linnaea 26:707. 1853. [as *Torula hypoxylaecola*]. Type:[as *Tolula hypoxylon*] in Herbarium, Preuss. (B). ≡*Oospora hypoxylicola* (Preuss) Sacc. & Voglino, Syll. Fung. 4:17. 1886. The arthrospores probably belonging to a Basidiomycete, fide W. Gams, *Cephalosporium*-artige Schimmelpilze (Hyphomycetes), p. 211. 1971.

253. ***T. hysterioides*** Corda, Icon. Fung. 1:9. 1837. Holotype: In ligno putrido ad Reichenberg. (PR!). ≡*Hormiscium hysterioides* (Corda) Sacc., Syll. Fung. 4:264. 1886. =*Cryptocoryneum condensatum* (Wallr.) E.W. Mason & S. Hughes ex S. Hughes, Rimington, Nat. Hist. Scarborough Dist. 1:161. 1953. Nom. Inval. Art. 33.3. ICBN; Canad. J. Bot. 36:758. 1958.

254. ***T. ignobilis*** P. Karsten & Har., J. Bot. 4:362. 1890. Holotype: Ad *Ulmus* sp., Méry-Sur- Seine, Gaule, 26 Août 1885. Hariot. (PC!). Isotype: (K!). Specimens contain light to dark brown, thick-walled cells which occasionally become 1-septate or dictyoseptate.

255. ***T. incrustans*** Ellis & Barthol. Nom. nud. Art. 32.1. ICBN. Specimen: On *Celtis occidentalis*, Kans. (NY).

256. ***T. inaequalis*** Corda, Icon. Fung. 3:5. 1839. Holotype: Auf morschen Stielen von *Echium*. (PR 155689!). ≡*Oospora inaequalis* (Corda) Saccardo & Voglino, Syll. Fung. 4:15. 1886. Material contains *Verticillium tenerum* (Nees) Link and *Scopulariopsis brevicaulis* (Sacc.) Bainier, but neither agree with the diagnoses, fide W. Gams, *Cephalosporium*-artige Schimmelpilze (Hyphomycetes), p. 211. 1971.

257. ***T. incarcerata*** Cooke, Grevillea 1:90. 1872. Holotype: On American cotton seeds, Dharwar, India. (K!). =*Aspergillus niger* Tiegh., fide Mason, Mycol. Pap. I.M.I. 2:25. 1928.

258. ***T. infirmo-miniata*** Okun., Jap. J. Bot. 5:319. 1931. Type culture: CBS 323. ≡*Rhodotorula glutinis* (Fresen.) F.H. Farrison var. *infirmo-miniata* (Okun.) Lodder, Verh. Kon. Ned. Akad. Wetensch., Afd. Natuurk., Tweede Section 32:115. 1934. ≡*Rhodotorula infirmo-miniata* (Okun.) T. Haseg. & I. Banno,

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Antonie van Leeuwenhoek 30:67. 1964. ≡*Cryptococcus infirmro-miniatus* (Okun.) Phaff & Fell in Lodder, The Yeasts, a Taxonomic Study, ed. 2, p. 1113. 1970. Teleomorph: *Cystofilobasidium infirmo-miniatum* (Fell, I.L. Hunter & Tallman) Hamam., Sugiy. & Komag., J. Gen. Appl. Microbiol. 34:276. 1988.

259. ***T. inquinans*** (Schwein.) Sacc., Syll. Fung. 4:251. 1886. ≡*Trichoderma globosum* Schwein., Schriften Naturf. Ges. Leipzig 1:77. 1822. Holotype: Ramis emortuis. *Liriodendri.* (PH!). Isotypes: (BPI!, K!, UPS!). ≡*Oidium inquinans* (Schwein.) Schwein. Trans. Amer. Phil. Soc. 4:286. 1832. ≡*Conoplea globosa* (Schwein.) S. Hughes, Canad. J. Bot. 36:755. 1958.
260. ***T. inops*** P. Karst. in Sacc., Syll. Fung. 15:416. 1901. An error for *T. olivacea* Corda subsp. *inops* P. Karst.
261. ***T. insularis*** Thüm., Flora 61:182. 1878. Presumed type: America septentr., Aiken, Carolina australis, ad *Quercus cinereae* Michx. folia languida aridave, Leg. H.W. Ravenel, in F. de Thüm., Mycotheca Universalis, Century XVIII, No. 1760. Anno 1880. (FH!, ILL!, L 910,256-2124!, NY!). ≡*Oospora insularis* (Thüm.) Sacc. & Voglino, Syll. Fung. 4:24. 1886. Based on brown, thick-walled hyphae.
262. ***T. inulacea*** F.C. Harrison, Proc. & Trans. Roy. Soc. Canada, Ser. 3, 21(Pt. 2, Sec. 5):375. 1927. =Blastomycete.
263. ***T. jaapii*** Lindau, in Rabenh. Krypt.-Fl., Zweite Auflage . Zweite Auflage. Erster Band, VIII Abt., p. 577. 1907. Holotype: Auf faulenden Stumpfen von *Pinus silvestris* bei Triglitz in Brandenburg. Leg. Jaap. Oktober. (B!). =*Alysidium resinae* (Fr.:Fr.) M.B. Ellis. See Rao & de Hoog, Persoonia 8:202. 1975.
264. ***T. janthina*** Thüm., Inst. Revista Scien. Litt., Coimbra (Coimbra Univ. Ist. Coimbra) 27:7-8. 1879. Holotype: In cortica sub vivo *Ficus carica* L., Cerca de St. Bento pr. Coimbra. November 1878, Leg. A. Möller No. 222. (K!). Type contains branched, septate, brown hyphae. Some phragmospores were also noted.
265. ***T. jeanselmei*** Langeron, in Jeanselme, L. Huet, & Lotte, Bull. Soc. Franc. Dermatol. 35:374. 1928; Ann. Parasitol. Humaine Syphiligr. 6(4):396. 1928. Type Cultures: CBS 507.90, IMH 283, ATCC 34123. ≡*Torulopsis jeanselmei* (Langeron) F.P. Almeida, Ann. Fac. Med. 9:76. 1933. ≡*Pullularia jeanselmei* (Langeron) C.W. Dodge, Medical Mycology, p. 675. 1935. ≡*Phialophora jeanselmei* (Langeron) C.W. Emmons, Arch. Pathol. 39:368. 1945. ≡*Phialophora jeanselmei* (Langeron) Coudert, Guide Pratique de Mycologie Médicale, p. 330. 1955. Nom. illeg. Art. 52.1. ICBN. ≡*Exophiala jeanselmei* (Langeron) McGinnis & A.A. Padhye, Mycotaxon. 5:345. 1977. ≡*Exophiala jeanselmei* (Langeron) McGinnis & A.A. Padhye var. *jeanselmei* , Stud. Mycol. 15:108. 1977. For further synonomy see McGinnis & Padhye, Mycotaxon 5:344-345. 1977.
266. ***T. juglandina*** Opiz, Seznam Rostlin Kveteny Ceské. p. 147, 364. 1852. Holotype: Bohemia centralia: Praha. IX. 1845. P.M. Opiz. (PR 704575!). =*Marssonina juglandis* (Lib.) Magnus.
267. ***T. kefir*** E.I. Nikolajewa, Izv. Imp. S.-Peterburgsk. Bot. Sada, 7:121-129. 1907. =Blastomycete.

See Errata

268. ***T. kefyr*** Beij., falsely so cited in the literature; originally described as *Sacharomyces kefyr* Beij., Arch. Néerl. Sci. Exact. Nat. 23:431. 1889. ≡*Mycotorula kefyr* (Beij.) F.C. Harrison, Proc. & Trans. Roy. Soc. Canada, Ser.3, 22(Pt. 1, Sec. 5):222. 1928. ≡*Geotrichoides kefyr* (Beij.) Langeron & Talice, Ann. Parasitol. Hum. Comp. 10:68. 1932. ≡*Torulopsis kefyr* (Beij.) Lodder, Verh. Kon. Ned. Akad. Wetensch., Afd. Natuurk., Tweede Section 32:134. 1934. ≡*Cryptococcus kefyr* (Beij.) C.E. Skinner, Amer. Midl. Natural ist 43:248.1950. ≡*Candida kefyr* (Beijerinck) Uden & H.R. Buckley in Lodder, TheYeasts, a Taxonomic Study, ed. 2, p. 980. 1970. Nom. Inval. Art. 33.3. ICBN.≡*Candida kefyr* (Beijerinck) Uden & H.R. Buckley in S.A. Meyer & Ahearn,Mycotaxon 17:297. 1983. Teleomorph: *Kluyveromyces maxianus* (E.C.Hansen) Van der Walt, Bothalia 10:418. 1971.

269. ***T. kephir*** sensu Guillierm., Les Levures, p. 446. 1912. Fasely attributed by Guilliermond to B. Henze & E. Cohn. Based on *Saccharomyces kefyr* Beij. ≡*Candida kefyr* (Beij.) Uden & H.R. Buckley.

270. ***T. kitaiana*** Traverso, Syll. Fung. 25:762. 1931. Based on a yeast isolated and described by G. Kita as *Torula* sp., Centralbl. Bakteriol., 2 Abt., 35:388. 1912. =Blastomycete.

271. ***T. kleinii*** J. Weiss, Journ. Med. Res. 7:289. 1902. [as *klein*]. ≡*Cryptococcus kleinii* (J. Weiss) Cohn, in F. Guég., Les Champignons Parasites de l'Homme et des Animaux, p. 114. 1904. =*Cryptococcus neoformans* (F. Sanfelice) Vuill., fide Lodder, The Yeasts, a Taxonomic Study, ed. 2, p. 1132. 1970. Teleomorph:*Filobasidiella neoformans* Kwon-Chung fide Kwon-Chung in Kurtzman & Fell, The Yeasts, a Taxonomic Study, ed. 4, p. 656. 1998.

272. ***T. koishikawensis*** K. Okunuki, Jap. J. Bot. 5:320. 1931. A conjugation strain of *Rhodosporidium toruloides* Banno, J. Gen. Appl. Microbiol. 13(2):193. 1967.

273. ***T. kortasii*** Dominik & Majchr., Ekol. Polska, Ser. A, 17:102. 1969. Type: Material destroyed, fide personal communication from Tadeusz Dominik. Appears to be based on terminal and intercalary, dark, thick-walled cells.

274. ***T. lactis*** (Adametz) Heinze & Cohn, Z. Hyg. Infektionskrankh. 46:358. 1904. ≡*Saccharomyces lactis* Adametz, Centralbl. Bakteriol., 1 Abt., Originale 5:116. 1889. Non *S. lactis* Dombrowski, 1910. =Blastomycete.

275. ***T. lactis-condensi*** B.W. Hammer, Iowa Agric. Exp. Sta. Res. Bull. 54:220. 1919. Type strain: CBS 52. ≡*Torulopsis lactis-condensi* (B.W. Hammer) Lodder & Kreger, fide Lodder & Kreger-van Rij, The Yeasts, a Taxonomic Study, ed. 1, p. 409. 1952. ≡*Candida lactis-condensi* (B.W. Hammer) Meyer & Yarrow, Int. J. Syst. Bacteriol. 28:613. 1978.

276. ***T. lactophila*** F.C. Harrison, Proc. & Trans. Roy. Soc. Canada, Ser. 3, 21(Pt. 2, Sec. 5):374. 1927. =Blastomycete.

277. ***T. lactosa*** F.C. Harrison, Proc. & Trans. Roy. Soc. Canada, Ser. 3, 21(Pt. 2, Sec.5):373. 1927. =*Candida kefyr* (Beij.) Uden & H.R. Buckley, apud Lodder, TheYeasts, a Taxonomic Study, ed. 2, p. 980. 1970.

278. ***T. lactosa*** Klayver in F.C. Harrison, Nom. nud. Art. 32.1. ICBN. ≡*Mycotorula lactosa* F.C. Harrison, Proc. & Trans. Roy. Soc. Canada, Ser. 3, 22(Pt. 1, Sec. 5):221. 1928. [as *lactose*]. A Nom. nud., fide Lodder & Kreger,

See Errata

The Yeasts, a Taxonomic Study, ed. 1, p. 512. 1952. =*Candida kefyer* (Beij.) Uden & H.R. Buckley.

279. ***T. lambica*** Kufferath, Ann. Soc. Zymol. 1:8. (1925) 1926. Nom. nud. Art. 32.1. ICBN. ≡*Mycotorula lambica* (Kufferath) F.C. Harrison, Proc. & Trans. Roy. Soc. Canada, Ser. 3, 22(Pt. 1, Sec. 5):220. 1928. ≡*Candida tropicalis* Castell. var. *lambica* (Kufferath) Diddens & Lodder, Die Anaskosporogenen Hefen, Sweite Halfte, p. 214. 1942. ≡*Candida tropicalis* var. *lambica* (Kufferath) Coudert, Guide Pratique de Mycologie Médicale, p. 263. 1955. Nom. illeg. Art. 52.1. ICBN. =*Candida sake* (Saito & M. Ota) Uden & H.R. Buckley, ex S.A. Meyer & Ahearn, Mycotaxon 17:298. 1983.

280. ***T. lamelligera*** El. & É.J. Marchal, Bull. Soc. Roy. Bot., Belgique 54:132. 1921. Type: Not located. From the description and illustration, this species appears to be based on terminal and intercalary, dark, thick-walled cells.

281 ***T. lanosa*** Szilviny, Zentralbl. Bakteriol., 2 Abt. 103:181. 1941. Type: Not located. Not identifiable from description.

282. ***T. laurentii*** Kuff., Ann. Soc. Roy. Sci. Med. Bruxelles 74:38. 1920. Type strain:CBS 139. ≡*Torulopsis laurentii* (Kuff.) Lodder, Verh. Kon. Ned. Akad. Wetensch. Amsterdam Afd. Natuurk., Section 2, 32:60. 1934. ≡*Cryptococcus laurenthii* (Kuff.) C.E. Skinner, Amer. Midl. Naturalist 43:249. 1950. ≡*Cryptococcus laurentii* (Kuff.) C.E. Skinner var. *laurentii*, fide Lodder, The Yeasts, aTaxonomic Study, ed. 2, p. 1120. 1970.

283. ***T. laxa*** (Wallr.) Rabenh., Deutschl. Krypt.-Fl., 1:34. 1844. ≡*Hormiscium laxum* Wallr., Fl. Crypt. Germ. 2:186. 1833. =*Dendryphion nanum* (Nees:Fr.) S. Hughes, Canad. J. Bot. 36:761. 1958.

284. ***T. lecanii-corni*** Benedek & Specht., Centralbl. Bakteriol., 1 Abt., Originale 130:86. 1933. Type Cultures: CBS 123.33, ATCC 12734, IMI 62462. ≡*Exophiala jeanselmei* (Langer.) McGinnis & A.A. Padhye var. *lecanii-corni* (Benedek & Specht) de Hoog, Stud. Mycol. 15:112. 1977.

285. ***T. lechleriana*** Sacc., Michelia 1:131. 1878. Holotype: In foliis vivis *Myrciae lechlerianae* Miq. in Valdivia, Chili, Oct. 1851. (PAD!). ≡*Hormiscium lechlerianum* (Sacc.) Sacc., Syll. Fung. 4:265. 1886. Based on metacapnodiaceous hyphae, some of which bear *Capnobotrys* conidiogenous cells, and a *Tripospermum*, fide Hughes, Mycologia 68:788. 1976.

286. ***T. lechleriana*** Thüm., Rev. Mycol. (Toulouse) 1:11. 1879. Nom. illeg. Art. 53.1. ICBN. ≡*Torula valdiviensis* Sacc., Syll. Fung. 4:260. 1886. Type: Chile, Colico prov. Valdivia ad *Bromeliae landbeckii* Lechl. folia subvirentia in sylvia umbrosis. I.1855, Leg. W. Lechler., Thümen, Fung. Novo. Exot. Dec. 1, No. 10. 1879. Not located.

287. ***T. lichenicola*** Linds., Trans. Roy. Soc. Edinburgh 25:515. 1869. Lectotype: Scotland, Perthshire, Loch Tay, on thallus and apothecia of *Lecanora chlarotera* Nyl. on *Fraxinus* by roadside, June 1856, W.L. Lindsay (E). ≡*Sirothecium lichenicola* (Linds.) Keissl., Oesterr. Bot. Z. 60:56. 1910. ≡*Vouauxiella lichenicola* (Linds.) Petr. & Syd., Repert. Spec. Nov. Regni Veg. Beih. 42:484. 1927. See Hawksworth, Bull. Brit. Mus. Nat. Hist., Bot. 6(3):287. 1979; Bull. Brit. Mus. Nat. Hist., Bot. 9(1):65-66. 1981.

288. ***T. lichenicola*** Lindsay forma *cerinae* de Lesd., Bull. Soc. Bot. France 55:424. 1908. ≡*Sirothecium lichenicola* forma *cerinae* (de Lesd.) Keissler, Centralbl.

Bakteriol., 2 Abt., Originale 27:210. 1910. Type: France, Cantal, Bois de Nuits, sur les apothécies du *Caloplaca cerina*, 1902, L'Abbé Charbonnel. (Destroyed). ?=*Lichenodiplis lecanorae* (Vouaux) Dyko & D. Hawksw., Lichenologist 11:52. 1979. See also Hawksworth, Bull. Brit. Mus. Nat. Hist., Bot. 6(3):287. 1979.

289. ***T. lichenopsis*** Höhn., Denkschr. Kaiserl. Akad. Wiss., Math.-Naturwiss. Kl. 83:36. 1927. Holotype: On indet., sterile, crustose lichen on bark, Sao Paolo, Brazil, July 1901, F. v. Höhnel 1275. (FH!). =*Cladosporium sphaerospermum* Penz. See Hawksworth, Bull. Brit. Mus. Nat. Hist., Bot. 6(3):287. 1979.

290. ***T. lichenum*** Keissler, Centralbl. Bakteriol., 2 Abt., Originale 37:388. 1913. Holotype: Hab. in hymenio peritheciorum *Staurothelis rispifragae* Arn. Ad lacum Leopoldsteiner-See prope Ersenerz. Alt. ca. 600, Junio 1910, Leg: C. de Keissler. (W!). Based on hyphae, vide Hawksworth, Bull. Brit. Mus. Nat. Hist., Bot. 6(3):287-288. 1979.

291. ***T. ligniperda*** (Willk.) Sacc., Syll. Fung. 18:565. 1906. ≡*Xenodochus ligniperda* Willk., Die mikroskopischen Feinde des Waldes, p. 67. 1866. Type: Not preserved. The identity of this species is doubtful, fide Rao & de Hoog, Persoonia 8:204. 1975.

292. ***T. lipofera*** Dooren de Jong, Ned. Tijdschr. Hyg. 1:145. (1926) 1927. Authen tic strain at CBS. ≡*Torulopsis lipofera* (Dooren de Jong) Lodder, Verh. Kon. Ned.Akad. Wetensch., Afd. Natuurk., Tweede Section 32:173. 1934. ≡*Cryptococcus lipoferus* (Dooren de Jong) Skinner, Amer. Midl. Naturalist 43:249. 1950. ≡*Lipomyces lipoferus* (Dooren de Jong) Lodder & Kreger, The Yeasts, aTaxonomic Study, ed. 1, p. 335. 1952. Teleomorph: *Lipomyces lipofer* Lodder& Kreger ex Slooff, The Yeasts, aTaxonomic Study, ed. 2, p. 393. 1970.

293. ***T. lipolytica*** B.J. Jacobsen, Verslagen Gewone Vergad. Wis-en Natuurk. Afd. Kon. Akad.Wetensch. Amsterdam 32, Nos. 1 & 2:22. 1923; Centraalbureau voor Schimmelcultures te Baarn, Lijst der Cultures 1923:4. Nom. nud. Art. 32.1. ICBN.

294. ***T. lipolytica*** (B.J. Jacobsen ex F.C. Harrison) Lodder, Verh. Kon. Ned. Akad. Wetensch. Amsterdam Afd. Natuurk., Sec. 2, 32:34, 47, 52. 1934. ≡*Mycotorula lipolytica* (B.J. Jacobsen) ex F.C. Harrison, Trans. Roy. Soc. Canada, Ser. 3, 22(Pt. 1, Sec. 5):215. 1928. Based on *T. lipolytica* B.J. Jacobsen, 1923. Nom. nud. Art. 32.1. ICBN. ≡*Candida lipolytica* (B.J. Jacobsen ex F.C. Harrison) Diddens & Lodder, Die Anaskosporogenen Hefen, 2 Hälfte, p. 321. 1942. ≡*Azymoprocandida lipolytica* (B.J. Jacobsen ex F.C. Harrison) Novák & Zsolt, Acta Bot. Acad. Sci. Hung. 7:132. 1961. Nom. Inval. Art. 33.3. ICBN. ≡*Candida lipolytica* (B.J. Jacobsen ex F.C. Harrison) Diddens & Lodder var. *lipolytica*, fide Uden & H.R. Buckely, in Lodder, The Yeasts, a Taxonomic Study, ed. 2, p. 991. 1970. Teleomorph: *Saccharomycopsis lipolytica* (Wickerham, Kurtzman & Herman) Yarrow. ≡*Yarrowia lipolytica* (Wickerham, Kurtzman & Herman) Van der Walt & Arx fide Kurtzmam in Kurtzmzm & Fell, The Yeasts, a Taxonomic Study, ed. 4, p. 420. 1998.

295. ***T. longispora*** Preuss in Sturm's, Deutschl. Flora III (Pilze), Bd. 6:9. 1848; Linnaea. 24:105. 1851. **Lectotype designated herein**: In ligno *Juglandis* molliore pr. Hoyerswerda. Preuss in Klotzschii Herb. Vivum Myc. Fung., Cent. 18, No. 1767. Anno 1853. (B!). Isolectotypes: (FH!, PR 777261!). ≡*Oospora longispora* (Preuss) Sacc. & Voglino, Syll. Fung. 4:20. 1886. ≡*Acremonium longisporum* (Preuss) Gams, *Cephalosporium*-artige Schimmelpilze (Hyphomycetes), p. 89. 1977.

296. ***T. lucifuga*** Oudem., Arch. Neerl. Sci. Exact. Nat. Ser. 2, 7:294. 1902. Type: No type available. The folder at (L) contains only the illustrations. The species appears to be based on terminal and intercalary, dark, thick-walled hyphae.

297. ***T. luteola*** Saito, Jap. J. Bot. 1:44. 1922. ≡*Chromotorula luteola* (Saito) F.C. Harrison, Proc. & Trans. Roy. Soc. Canada, Ser. 3, 22(Pt. 1, Sec. 5):202. 1928. ≡*Torulopsis luteola* (Saito) Lodder, Verh. Kon. Ned. Akad. Wetensch. Amsterdam Afd. Natuurk., Sec. 2, 32:169. 1934. ≡*Cryptococcus luteolus* (Saito) C.E. Skinner, Henrici's Molds, Yeasts, and Actinomycetes, ed. 2, p. 289. 1947. Nom. Inval. Art. 34.1. ICBN. ≡*Cryptococcus luteolus* (Saito) C.E. Skinner, Amer. Midl. Naturalist 43:249. 1950.

298. ***T. luzulae*** Fuckel, Hedwigia 5:30. 1866; Fungi Rhen. Exs. Supp., Fascicle 2, No. 1624. Anno 1866; Symb. Mycol., p. 348. 1970. **Lectotype designated herein**: Ad *Luzulae maxime* folia putrida, in Sylva Hostrichiensi, F. R. E. No. 1624. (G!). Isolectotypes: (FH!, K!, L!, NY!, UC 955235!). ≡*Gliomastix luzulae* (Fuckel) Mason ex S. Hughes, Canad. J. Bot. 36:769. 1958. ≡*Sagrahamala luzulae* (Fuckel) Subram., Curr. Sci. 41:48. 1972.].

299. ***T. macrotricha*** Corda, Icon. Fung. 1:8. 1837. Type: Not located. ≡*Oospora macrotricha* (Corda) Sacc. & Voglino, Syll. Fung. 4:24. 1886. Not identifi able, fide W. Gams, *Cephalosporium*-artige Schimmelpilze (Hyphomycetes), p. 212. 1971.

300. ***T. maculans*** Cooke, Grevillea 7:35. 1878. Holotype: On Yucca leaves (*Yucca filamentosa*), Darien 2569, Aiken, S. Ca., H.W. Ravenel. (K!). ≡*Periconia maculans* (Cooke) J.L. Crane & Schokn., Mycologia 67:667. 1975.

301. ***T. maculans*** Cooke var. ***biformis*** Sacc., Nuovo Giorn. Bot. N.S. 27:85. 1920. Holotype: Hab. in foliis emortuis *Yuccae glaucae*, Wheatland, Wyoming, Coll. James R. Weir, June 4, 1917, No. 10861. (PAD!). =*Periconia maculans* (Cooke) J.L. Crane & Schokn.

302. ***T. maculicola*** Romell & Sacc. in Sacc., Grevillea 21:69. 1893. Lectotype: On *Populus tremula* L., Suecia, Sodermanland: Nacka, Vikdalen 24. VI. 1890, Leg. L.G. Romell No. 17688.(S!). Isolectotypes: B!, WINF(M) 11082!. ≡*Phaeoramularia maculicola* (Romell & Sacc.) B. Sutton, Canad. J. Bot. 489:471. 1970. ≡*Cladosporium maculicola* (Romell & Sacc.) Morelet, Bull. Soc. Sci. Nat. Archeol. Toulon 201:4. 1972. [as *maculicolum*].

303. ***T. maculosa*** Speg., Dec. Mycol. Ital. Sub. No. 85, 1 Nov. 1879. Nom. nud. Art. 32.1. ICBN. Associated with *Apiosporium maculosum* Speg. **Lectotype designated herein**: Ad folia *Rhododendron chamaecistus* Dec. Mycol. Ital. No. 85. (BPI!). ≡*Cladotrichum maculosum* (Speg.) ex Sacc., Michelia 2:171. 1880. Hyphopodiate (?Meliolaceous) mycelium was observed on leaves and stems.

304. ***T. ?major*** G. Arnaud, Bull. Soc. Mycol. France 69:276. 1954. Nom. nud. Art. 32.1. ICBN. Holotype: P. Arnaud No. 2420. (PC!). Type material contains *Clonostachys compactiuscula* (Sacc.) D. Hawksw. and *Torula herbarum.* (Pers.) Link:Fr.

305. ***T. maltosa*** F.C. Harrison, Trans. Roy. Soc. Canada, Ser. 3, 21(Pt. 2, Sec. 5):372. 1927 [as *maltose*]. =Blastomycete.

306. ***T. mansonii*** (Castell.) Vuill., Compt. Rend. Hebd. Séances Acad. Sci. 189:406. 1929 [as *mansoni*]. ≡*Microsporum mansonii* Castell., Brit. Med. J. 1905(2):1271 1905 [as *Microsporom*]. Neotype Culture: CBS 158.58, designated by de Hoog, 1977. Isoneotype Culture: ATCC 18657 isolated by A. Castellani from a human patient, Ceylon, 1905. ≡*Foxia mansonii* (Castell.)Castell., J. Trop. Med. Hyg. 11:261. 1908 [as *mansoni*]. ≡*Cladosporium mansonii* (Castell.) Castellani & Chalmers, Manual of Tropical Medicine,p. 1100. 1919. Falsely cited as published by Pinoy in Ann. Dermatol.Syphiligr., Ser. 5, 3:341-343. 1912. ≡*Malassezia mansonii* (Castell.) Verdun,Précis de Parasitologie Humaine, ed. 2, p. 698. 1913 [as *mansoni*].≡*Dematium mansonii* (Castell.) C.W. Dodge, Medical Mycology, p. 678.1935 [as *mansoni*]. ≡*Aureobasidium mansonii* (Castell.) W.B. Cooke, Mycopathol. Mycol. Appl. 17:34. 1962. Non *Rhinocladiella mansonii* (Castell.)Schol-Schwarz, Antonie van Leeuwenhoek 34:122. 1968. Non *Exophiala mansonii* (Castell.) de Hoog, Stud. Mycol. 15:114. 1977. Non *Exophiala castellanii* Iwatsu, Nishim. & Miyaji, Mycotaxon 20:307. 1984. Holotype: IFM 4702. =*Malassezia furfur* (Robin) Baillon.

307. ***T. mansonii*** (Castell.) Brumpt, Précis de Parasitologie, ed. 5, Vol. 2, p. 1791. 1936. Nom. illeg. Art. 52.1. ICBN. Non *Exophiala mansonii* (Castell.) deHoog. = *Malassezia furfur* (Robin) Baillon.

308. ***T. mansonii*** (Castell.) Coudert, Guide Pratique de Mycologie Médicale, Paris, p. 273. 1955 [as *mansoni*]. Nom. illeg. Art. 52.1. ICBN. Non *Exophiala mansonii* (Castell.) de Hoog. = *Malassezia furfur* (Robin) Baillon.

309. ***T. marginata*** L.W.R. Jackson, Phytopathology 35:98. 1945. Holotype: On *Pinus echinata*, Coll. and Det. L.W.R. Jackson, F.P. 90914. (BPI!). =*Alysidium resinae* (Fr. : Fr.) M.B. Ellis.

310. ***T. medullae*** Schwein., Trans. Amer. Philos. Soc. II, 4:286. 1832. Holotype: Bethlehem, Pennsylvania. (PH!). Specimen contains terminal and intercalary, thick-walled cells, possibly of a *Verticillium.*

311. ***T. mellis*** Fabian & Quinet, Michigan Agric. Exp. Sta. Techn. Bull. No. 92:20 (diag.), 29 (nomen). 1928. Type Culture: From honey, CBS 350.33. ≡*Moniliella mellis* (Fabian & Quinet) V.G. Rao & de Hoog, Persoonia 8:205. 1975.

312. ***T. membranacea*** F.C. Harrison, Trans. Roy. Soc. Canada, Ser. 3, 21(Pt. 2, Sec. 5):361. 1927. =Blastomycete.

313. ***T. meningitis*** C.W. Dodge, Medical Mycology, p. 897. 1935. Erroneously so cited for *Cryptococcus meningitidis* C.W. Dodge, Medical Mycology, pp. 329-333. 1935.

314. ***T. menzelii*** (Corda) Fr., Summa Veg. Scand. 2:505. 1849. ≡*Bispora menzelii* Corda, Icon. Fung 1:9. 1837. Type: PR. =*Bispora antennata* (Pers.) Mason fide Hughes, Canad. J. Bot. 36:741. 1958.

315. ***T. microsora*** Thüm., Flora 61:182. 1878. Holotype: America septentr.: Aiken, Carolina australis, Ad caules emortuos *Amsoniae angustifoliae* Michx. 1877; H.W. Ravenel No. 2250. (BM!). Probable Isotypes: Thümen, Mycotheca Universalis, Century XV, No. 1475. Anno 1879. (FH!, ILL!, L 910,256-2118!, NY!). The type material contains dark brown, subglobose, scattered, immersed fruiting bodies. Material at NY also contained chains of oval, light brown cells constricted at septa, 4.4 µm wide.

316. ***T. mineralis*** Hayduck & Haehn ex F.C. Harrison, Trans. Roy. Soc. Canada, Ser. 3, 22(Pt. 1, Sec. 5):211. 1928. [as Haydruck]. =*Candida utilis* (Henneberg) Lodder & Rij fide Kurtzman in Kurtzman & Fell, The Yeasts, a Taxonomic Study ed. 4, p. 314. 1998. Teleomorph: *Pichia jadinii* (A. & R. Sartory, Weill & J. Meyer) Kurtzman in Kurtzman & Fell, Ibid. p. 314. 1998.

317. ***T. miniata*** K. Okunuki, Jap. J. Bot. 5:320. 1931. Authentic culture from Okunuki at CBS. =*Rhodotorula glutinis* (Fresen.) F.C. Harrison var. *glutinis*, fide Lodder, The Yeasts, a Taxonomic Study, ed. 2, p. 1194. 1970.

318. ***T. minuta*** Saito, Jap. J. Bot. 1:48-49. 1922. Type Culture: CBS 319. ≡*Torulopsis minuta* (Saito) Cif. & Redaelli, Atti Ist. Bot. Univ. Pavia Ser. 3, 2:261. 1925. ≡*Rhodotorula minuta* (Saito) F.C. Harrison var. *minuta* fide Lodder, The Yeasts, a Taxonomic Study, ed. 2, p. 1206. 1970.

319. ***T. modica*** F.C. Harrison, Trans. Roy. Soc. Canada, Ser. 3, 21(Pt. 2, Sec. 5):369. 1927. =Blastomycete.

320. ***T. molischiana*** Zikes, Zentralbl. Bakteriol. 2 Abt., 30, 634. 1911. Type Cultures: IFO 0646, NRRl Y-2237, ATCC 2516. ≡*Torulopsis molischiana* (Zikes) Lodder, Verh. Kon. Ned. Akad. Wetensch. Afd. Natuurk., Sec. 2, 32:138. 1934. ≡*Cryptococcus mollischianus* (Zikes) C.E. Skinner, Amer. Midl. Natural ist 248. 1950. ≡*Candida molischiana* (Zikes) Meyer & Yarrow, Int. J. Syst. Bacteriol. 28:613. 1978. Teleomorph: *Pichia capsulata* (Wick.) Kurtzman fide Kurtzman in Kurtzmzn & Fell, The Yeasts, a Taxonomic Study, ed. 4, p. 296. 1998.

321. ***T. monilioides*** Corda in Sturm's, Deutschl. Flora III (Pilze), Bd. 2, Heft 8:83. 1829. Type:Not located. Not identifiable from the description.

322. ***T. monilioides*** Corda var. ***globosa*** Ferraris, Malpighia 16:39-40. 1902. Type: Not located. Not identifiable from description.

323. ***T. monilioides*** (Corda) Fr., Summa Veg. Scand. 2:505. 1849. ≡*Bispora monilioides* Corda, Icon. Fung. 1:9. 1837. Type: PR. =*Bispora antennata* (Pers.) Mason, in S. Hughes, Canad. J. Bot. 31:582. 1953.

324. ***T. monilis*** Persoon, Ann. Bot. (Usteri) 15:25. 1795. ≡*Monilia herbarum* Pers., Syn. Meth. Fung., p. 693. 1801. ≡*Torula herbarum* (Pers.) Link:Fr.

325. ***T. monosa*** Kluyver, Biochemische suikerbepalingen, Diss. Delft., Leiden, p. 16. 1914. ≡*Mycotorula monosa* (Kluyver) F.C. Harrison, Trans. Roy. Soc. Canada, Ser. 3, 22(Pt. 2, Sec. 5):218. 1928. ≡*Candida monosa* (Kluyver) Diddens & Lodder, Die Anaskosporogenem Hefen, Zweite Halfte, p. 276. 1942. =*Candida lambica* (Lindner & Genoud) Uden & H.R. Buckley in

Lodder, The Yeasts, a Taxonomic Study, ed. 2, p. 986. 1970. Teleomorph: *Pichia fermentans* Lodder fide Kurtzman in Kurtzman & Fell, The Yeasts, a Taxonomic Study, ed. 4, p. 305. 1998.

326. ***T. monosporia*** (Westend.) J. Kickx f., Fl. Crypt. Flandres 2:301. 1867. ≡*Oidium monosporium* Westend., Bull. Soc. Roy. Bot. Belgique 2:252. 1863. ≡*Ovularia monosporia (Westend.)* Keissl. in Zahlbr., Ann. K.K. Naturhist. Hofmus 29:462. 1915. Type: Not located. Unidentifiable from description.

327. ***T. morrhuae*** (Farl.) Sacc. in Trotter, Syll. Fung. 25:762. 1931. A Nom. Nov. for *T. pulvinata* (Farl.) Farl. ≡*Oidium morrhuae* Farlow, Bull. U.S. Fish Commiss. 6:4. 1886. Holotype: On salt cod fish, Gloucester, Mass., Prof. Hyatt (FH!). =*Wallemia sebi* (Fr.:Fr.) Arx.

328. ***T. mucilaginosa*** Jörg., Die Mikroorganismen der Gärungsindustrie 5te Aufl. Berlin, p. 402. 1909. Investigated strain at CBS. ≡*Torulopsis mucilaginosa* (Jörg.) Cif. & Redaelli, Atti Ist. Bot. Univ. Pavia, Ser. 3, 2:256. 1925. ≡*Rhodotorula mucilaginosa* (Jörg.) F.C. Harrison, Proc. & Trans. Roy. Soc. Canada, Ser. 3, 22(Pt 1, Sec. 5):191. 1928. =*Rhodotorula rubra* (Demme) Lodder, The Yeasts, a Taxonomic Study, ed. 2, p. 1215. 1970.

329. ***T. muisa*** G. Mattlet, Ann. Soc. Belge Med. Trop. 6:25. 1926. ≡*Geotrichum muisa* (G. Mattlet) C.W. Dodge, Medical Mycology, p. 220, 1935. From the illustration, this species appears to be based on terminal and intercalary, thick-walled cells.

330. ***T. multiformis*** Preuss, Linnaea 26:707. 1853. Holotype: Auf halbverfaulten Blattern von *Hemerocallis coerulea* (B). ≡*Oospora multiformis* (Preuss) Sacc. &Voglino, Syll. Fung. 4:14. 1886. Type material was examined and found to be indiscernible by W. Gams, *Cephalospsorium*-artige Schimmelpilze (Hyphomycetes), p. 214. 1971.

331. ***T. multispora*** K.B. & K.S. Deshp., Sci. & Cult. 32:320. 1966. Type not available. From the author's illustrations and description, this species is based on terminal and intercalary, thick-walled cells.

332. ***T. muriae*** (J. Kickx f.) Vesterg., Micromycetes Rariores Selecti, Fascicle XXII, No. 550, issued May 1902. ≡*T. epizoa* Corda var. *muriae* J. Kickx f., Mem. Acad. Roy. Sci. Lett. Brussels 20:44. 1847. =*Wallemia sebi* (FR.:Fr.) Arx.

333. ***T. murorum*** Corda, Icon. Fung. 2:9. 1838. Type: PR. ≡*Gliomastix murorum* (Corda) S. Hughes, Canad. J. Bot. 36:769. 1958.

334. ***T. mycetophila*** Cooke & Massee, Grevillea 16:3. 1887. Holotype: On pileus of *Polyporus cinnabarinus*, Victoria (Campbell 388). (K!). Based on mycelium.

335. ***T. myxococci-incrustantis*** E. Zederbauer, Akad. Wiss. Wien Sitzungsber. Math.-Naturwiss. Kl. Abt. 1, 112:475. 1903. Type: Not located. Not identifiable from the description.

336. ***T. nasalis*** F.C. Harrison, Proc. & Trans. Roy. Soc. Canada, Ser. 3, 22(Pt. 2, Sec. 5):207. 1928. ≡*Cryptococcus nasalis* (F.C. Harrison) C.W. Dodge, Medical Mycology, p. 332. 1935. =*Cryptococcus neoformans* (F. Sanfelice) Vuill. fide Kwon-Chung in Kurtzman & Fell, The Yeasts, a Taxonomic Study, ed. 4, p. 656. 1998.

337. ***T. ndjilensis*** E. Kiffer, Naturaliste Canad. 100:257. 1973. Holotype: Isolated from soil, Ndjile, Kinshasa, Zaire, E. Kiffer, (IMI 171803!). =*Bahusandhika caligans* Bat. & H.P. Upadhyay.
338. ***T. negeri*** Delitsch, Systematik der Schimmelpilze in Ergebnisse der Theoretischen und Angewandten Mikkrobiologie Bd. 1, p. 118. 1943. Type: Not located. From the illustration, this species is not a *Torula*.
339. ***T. neoformans*** (F. Sanfelice) J. Weiss, J. Med. Res. 7:294. 1902. ≡*Saccharomyces neoformans* F. Sanfelice, Ann. Ig. Sperim. 5:241. 1895. ≡*Torulopsis neoformans* (F. Sanfelice) F.P. Almeida, Ann. Fac. Med. Sao Paulo 9:76. 1933. ≡*Torulopsis neoformans* (F. Sanfelice) Nann., Repertorio Sistematico dei Miceti dell' Uomo e degli Animali, p. 328. 1934. Nom. illeg. Art. 52,1. ICBN. ≡*Torulopsis neoformans* (F. Sanfelice) Lodder, Verh. Kon. Ned. Akad. Wetensch., Afd. Natuurk., Tweede Section 32:155. 1934. Nom. illeg. Art. 52.1. ICBN. =*Blastomyces neoformans* Arzt, falsely so cited as published in Arch. Derm. Syph. Berlin 145:311. 1925 by C.W. Dodge, Medical Mycology, p. 330. 1935, and F. Petrak, Just's Bot. Jahresber. 63(1935), Abt. 2, p. 824. 1944. ≡*Cryptococcus neoformans* (F. Sanfelice) Vuill., Rev. Gen. Sci. Pures Appl. 12:747. 1901.
340. ***T. nigra*** Nom. nud. Art. 32.1. ICBN. A name attributed to Lindner and relegated to synonymy by L. Berger & Langeron, Ann. Parasitol. Humaine Comp. 24:588. 1949, for a fungus isolated from air by Zeidler in Moscow (Souche de Moscow) and investigated by Lindner, Wochenschr. Brauerei 4:853. 1887. =*Aureobasidium pullulans* (de Bary) G. Arnaud, fide L. Berger & Langeron as *Pullularia pullulans* (de Bary) Berkhout.
341. ***T. nigra*** (Burri & W. Staub) Sacc. & Traverso, Syll. Fung. 20:964. 1911. Type: Not located. ≡*Monilia nigra* Burri & W. Staub, Landw. Jahrb. Schweiz. 1909:512. 1909. =*Moniliella suaveolens* (Linder ex Lindner) Arx, fide de Hoog & M.T. Smith in Kurtzman & Fell, The Yeasts, a Taxonomic Study, ed. 4, p. 787. 1998.
342. ***T. nigra*** (Marpmann) Guilliermond, Les Levures. Doin et Fils, Editeurs. Paris, p. 460. 1912. Nom. illeg. Art. 53.1. ICBN. ≡*Saccharomyces niger* Marpmann, Arch. Pharm. 224:708. 1886; Zentralbl. Allg. Gesundheitspflege 1886:423. 1886. =Blastomycete.
343. ***T. nikitinskii*** (Malevich) ex Panas., Mycologia 56:806. 1964. ≡*Oospora nikitinskii* Malevich, Microbiologia 5:814. 1936. Nom. nud. Art. 32.1. ICBN. Type: In culturis ex pisci salso. Not located. =*Oospora halophila* J.F.H. Beyma fide W. Gams, *Cephalospsorium*-artige Schimmelpilze (Hyphomycetes), p. 214. 1971.
344. ***T. nivea*** Fuckel, Symb. Mycol., p. 91. 1870. **Lectotype designated herein**: Auf faulem *Quercus*-Holz, Fungi Rhen. No. 1750 sub *Preussia funiculata* L. Fuckel. (GRO!). ≡*Oospora nivea* (Fuckel) Sacc. & Voglino in Sacc., Syll. Fung. 4:16. 1886. The specimen contains irregularly verticillately branched conidiophores which may belong to a hyaline- spored *Myrothecium* species. Positively not the conidial state of *Preussia funiculata* Fuckel, fide W. Gams, *Cephalosporium*-artige Schimmelpilze (Hyphomycetes), p. 214. 1971.

345. ***T. nodulosa*** (Sappa & Mosca) E. Castell., Elenco Annotato dei Funghi della Somalia (Firenze, Italy: Biblioteca Agraria Tropicale), p. 74. 1988. Nom. inval. Art. 33.3. ICBN. ≡*Hormiscium nodulosum* Sappa & Mosca, Allionia 2(1):218. 1954. Holotype: In culturis e solo apud Malaille (Guiba-Somalia). Type not seen. From the original description and illustration, the fungus is based on mycelium.

346. ***T. novae-carlsbergiae*** Grönlund, Dansk Naturhist. Forening, Copenhagen, Videnskabelige Meddel. 44:1. (1892) 1893. =Blastomycete.

347. ***T. nucleata*** Cooke, Grevillea 16:79. 1888. Holotype: On herb. stems, Shroffeld's Wood, April 26, 1855, F. Currey. (K!). =*Torula herbarum* (Pers.) Link:Fr.

348. ***T. obducens*** P. Karst., Meddeland. Soc. Fauna Fl. Fenn. 16:26. 1888. Holo type: Supra corticem semivivum *Populi tremulae*. Tavastia australis. Tammela, Mustiala, Finland, 25. I. 1882, Leg. P.A. Karsten No. 1098. (H!). =*Trimmatostroma betulinum* (Corda) S. Hughes.

349. ***T. obvia*** F.C. Harrison, Proc. & Trans. Roy. Soc. Canada, Ser. 3, 21(Pt. 2, Sec. 5):360. 1927. =Blastomycete.

350. ***T. occulta*** Ellis & Barthol., Erythea 4:50. 1897. Holotype: Inside old elm post, Rooks County, Kansas, May 11, 1986, Coll. E. Bartholomew No. 2132, (FH!), Isotype: (NY!,). ≡*Bispora occulta* (Ellis & Barthol.) J.L. Crane & Schokn., Mycologia 69:533-534. 1977.

351. ***T. ochracea*** Corda, Icon. Fung. 4:24. 1840. ≡*Oospora ochracea* (Corda) Sacc. &Voglino, Syll. Fung. 4:23. 1886. Type: Not preserved. Perhaps a *Scopulariopsis* sp., fide W. Gams, *Cephalosporium*-artige Schimmelpilze (Hyphomycetes), p. 214. 1971.

352. ***T. oleae*** Castagne, Cat. Pl. Marseille, p. 222. 1845. Authentic material: Ad folia et corticem olearum misit J.L. Castagne, M.A. Curtis Herbarium (FH!). ≡*Hormiscium oleae* (Castagne) Sacc., Syll. Fung. 4:265. 1886. ?=*Aureobasidium pullulans* (de Bary) G. Arnaud fide Ciferri, Sydowia 11:282. 1957; W.B. Cooke, Mycopathol. Mycol. Appl. 12:1. 1959. ≡*Aureobasidium oleae* (Castagne) Subram., Hyphom., p. 411. 1971.

353. ***T. olivacea*** Corda, Icon. Fung. 1:8. 1837. Type: [On rotten wood.] (Scr. Corda (PR 155691!). ≡*Hormiscium olivaceum* (Corda) Bonord., Handb. Mykol., p. 33. 1851. =*Torula herbarum* (Pers.) Link:Fr.

354. ***T. olivacea*** Corda var. ***erecta*** Corda, Icon Fung. 4:24. 1840. Type: PR!. =*Gliomastix murorum* (Corda) S. Hughes, Canad. J. Bot. 36:769. 1958.

355. ***T. olivacea*** Corda subsp. ***inops*** P. Karst., Hedwigia 29:272. 1890. Type: In ligno vetusto pini ad Mustiala [Finland], Automno sero, P.A. Karsten 1107 (H!). =*Xylohypha curta* (Corda) S. Hughes, Canad. J. Bot. 36:824. 1958; S. Hughes & Sugiy., New Zealand J. Bot. 10:457. 1972.

356. ***T. olivacens*** Schwein., Trans. Amer. Phil. Soc. Ser. II, 4:286. 1832. **Lectotype designated herein**: In libro corticis, epidermide orbato, *Catalpae*, Bethl. (PH!). Isolectotype: BPI!, K!. Authentic material: FH!. =*Torula herbarum* (Pers.) Link Fr.:Fr., fide Hughes, Canad. J. Bot. 36:818. 1958.

357. ***T. opaca*** Cooke in Sacc., Syll. Fung. 10:574. 1892. Lectotype: On bark of various dead and living shrubs, Newfield, N.J., Nov. 1881, Ellis, N. Amer. Fungi, Cent. VIII, No. 759. Anno 1882. (NY!). See

Hawskworth, Bull. Brit. Mus. Nat. Hist. Bot. 6:288. 1979. Isolectotypes: (FH!, ILL!, K!, NYS!). =*Taeniolella breviuscula* (Berk. & M.A. Curtis) S. Hughes.

358. ***T. opuntiae*** Reichert, Bot. Jahresb. Syst. 56:718. 1921. Holotype: In cladoniis *Opuntiae fici-indicae* (L.) Mill. apud Kahiram, 1822/25. (B!). =*Gliomastix luzulae* (Fuckel) Mason ex S. Hughes.
359. ***T. orthoclada*** Mont., Ann. Sci. Nat. Bot., Ser. 2, 17:119. 1842. Holotype: Ad caules herbarum prope Alequízar lecta, [Cuba]. (PC!). =*Torula herbarum* (Pers.) Link:Fr.
360. ***T. otanii*** Kimata, J. Appl. Mycol. Hokkaido Univ. 3:49. 1949. Nom. inval. Art. 32.1. =Blastomycete.
361. ***T. otophila*** C.O. Harz, Jahresber. Konige. Thierarztlichen Hochschule in Munchen 1892-1893:60-66. 1893. ≡*Torulopsis otophila* (C.O. Harz) Coudert, Guide Pratique de Mycologie Médicale. Possibly a *Scopulariopsis* sp.
362. ***T. ovalispora*** Berk. in J.E. Smith's English Flora 5(2):359. 1836. Holotype: "Torula ovalispora Berk", Milton, Norths. ex herb. Berk. Herb. Hookerianum 1867. (K). =*Oospora ovalispora* Sacc. & Voglino, Syll. Fung. 4:13. 1886. =*Xylohypha nigrescens* (Pers.:Fr.) E.W. Mason, fide S. Hughes, New Zealand J. Bot. 10:448. 1972.

363 ***T. ovicola*** O.E.O. Zimmermann, Ber. Naturwiss. Ges. Chemnitz 6:41-42. 1878. [as *ovicula*]. Type: Not located. ≡*Oospora ovicola* (O.E.O. Zimmermann) Sacc. & Traverso, Syll. Fung. 22:1241. 1913. Not identifiable from the description.

364. ***T. ?ovoidea*** G. Arnaud, Bull. Soc. Mycol. France 69:274. 1954. Nom nud. Art. 32.1. ICBN. Very probably represents *Xylohypha ferruginosa* (Corda) S. Hughes, New Zealand J. Bot. 10:452. 1972.
365. ***T. paisii*** Pollacci, Atti Ist. Bot. Univ. Pavia Ser. 2, 18:130. 1921. Type not located. Culture as Sc. 84, July 1959, (CBS) was investigated by Morton & Smith. ≡*Phaeoscopulariopsis paisii* (Pollacci) M. Ota, Jap. J. Dermatol. Urol. 23:405. 1928. Nom. inval. Art. 34.1. ≡*Scopulariopsis paisii* (Pollacci) Nann., Repert Mic. Uomo. Trattato di Micopatologia Umana 4, pp. 259-260. 1934. =*Microascus desmosporus* (Lechmere) Curzi, fide F.J. Morton & G. Smith, Mycol. Pap. I.M.I. 86:29. 1963.
366. ***T. pallida*** Berk. & Ravenel, Grevillea 3:14. 1874. Holotype: *Hydrangeam*, Nov., Charleston, S.C., H.W. Ravenel No. 1438. (K). Isotype: (FH!). Authentic material: On *Hydrangea* from Charleston, S.C., in H.W. Ravenel Coll. (CHARL!). ≡*Oospora pallida* (Berk. & Ravenel) Sacc. & Voglino, Syll. Fung. 4:24. 1886. This species appears to be based on branched, septate, light brown hyphae with constrictions at septa.
367. ***T. palmicola*** Berk. & M.A. Curtis, J. Linn. Soc. Bot. 10:353. 1868. Holotype: On leaves of prickly palm, February, [Cuba], Leg. C. Wright (564) (K!). Isotype: (FH!). Based on the hyphae of a sooty mold. The type specimen contains the thallus of *Trichopeltheca* sp. and cylindrical hyphae with a *Hormisciomyces* anamorph.
368. ***T. palmigena*** Bubák, Növényt. Közlem. 6(Heft 4):(55). 1907. Holotype: In foliis *Phoenicis dactyliferae*, Hungaria Hortus Botanicus, V, 1853. Leg.

Mágocsy-Dietz (Linhart, Fungi Hungar. No. 199). (BPI!). =*Graphiola phoenicis* (Mougeot:Fr.) Poiteau.

369. ***T. papillata*** Bonord., Bot. Zeitung Berlin 19:195. 1861. ≡*Oidium papillatum* (Bonord) Sacc. & Voglino, Syll. Fung. 4:46. 1886. From the description and illustration, this species may be an *Acrosporium*.

370. ***T. parallela*** Preuss, Linnaea. 24:104. 1851. ≡*Oospora parallela* (Preuss) Sacc. & Voglino, Syll. Fung. 4:14. 1886. Holotype: Auf verrottenden stark verschmutzten Roggenhalmen (B!). Not identifiable, fide W. Gams, *Cephalosporium*-artige Schimmelpilze (Hyphomycetes), p. 215. 1971.

371. ***T. peckii*** Sacc. & P. Syd., Syll. Fung. 14:1070. 1899. ≡*Torula ramosa* Peck, Rep. State Bot. New York State Mus. 32:39. 1880 [as 1879]. Non Fuckel. 1870. =*Alysidium resinae* (Fr.:Fr.) M.B. Ellis.

372. ***T. pedicellata*** Preuss in Sturm's, Deutschl. Flora III (Pilze), Bd. 6:15. 1848; Linnaea. 24:105. 1851. ≡*Oospora pedicellata* (Preuss) Sacc. & Voglino, Syll. Fung. 4:13. 1886. **Lectotype designated herein**: In *Corchori japonici* ramis putridis pr. Hoyerswerda, cla. Preuss in J.F. Klotzsch, Klotzschii Herb. Vivum Myc. Fung., ed. 1, Cent. 18, No. 1765. Anno 1853. (L!). Isolectotypes: (FH!, PR 777270!). The type material examined most closely corresponds to *Acremonium persicinum* (Nicot) W. Gams.

373. ***T. pentosa*** F.C. Harrison, Proc. & Trans. Roy. Soc. Canada, Series 3, 21(Pt. 2, Sec. 5):363. 1927. =Blastomycete.

374. ***T. periclymeni*** Oud., Ned. kruidk. Arch. Ser. 3, 1:523. 1898. Holotype: In ramis *Lonicera caprifolium*, Nunspeet, 21 Fevr. 1898, Leg. Beins No. 10. (L!). The type specimen, on stems, contains branched, septate, light brown hyphae with empty fruiting bodies.

375. ***T. perpusilla*** Sacc., Myc. Ven. Cent. 11, No. 1056. 1876; Michelia 1:265. 1878. ≡*Oospora perpusilla* (Sacc.) Sacc., Fungi Italici Fasc.17-28, Pl. 881. 1881. **Lectotype designated herein**: Selva (Treviso), in foliis variis putridis, Oct. 1876, M.V. No. 1056. (PAD!). Isolectotype:(FH!). The type material bears *Chlamydomyces palmarum* (Cooke.) Mason, *Verticillium* sp., and an Actinomycete with chains of 1-celled, hyaline, globose spores about 1/3 µm which fits the original description.

376. ***T. pettiti*** Hranova, Compt. Rend. Hebd. Séances Acad. Sci. 92:672. 1925. ≡*Cryptococcus pettiti* (Hranova) Nann., Repert. Sist. miceti d'ell Uomo e degli Animali Siena, Meini. (Trattato di micropatologia umano) 4:318. 1934. ≡*Torulopsis pettiti* (Hranova) Coudert, Guide Pratique de Mycologie Médicale, p. 249. 1955.

377. ***T. peyronelii*** Sacc., Nuovo Giorn. Bot. Ital. N. S. 22:70. 1915. Holotype: Funghi di Malta, leg. Caruana-Gatto. PAD!. =*Coniosporium diversum* (Cooke) Crane & Schokn.

378. ***T. phaea*** Corda, Icon. Fung. 1:8. 1837. Holotype: In caulibus Umbelliferarum exsicc. Prope Reichenberg. (PR 155693!). =*Torula herbarum* (Pers.) Link:Fr.

379. ***T. photographa*** Biourge, Nom. nud. Art. 32.1. ICBN. A strain isolated by Biourge but never described by him. It was named *Sporobolomyces photographus* Cif. & Redaelli, Atti Ist. Bot. Univ. Pavia Ser. 3, 2:248-251.

1925. =*Sporobolomyces roseus* Kluyver & C.B. Niel, fide Lodder, The Yeasts, a Taxonomic Study, ed. 2, p. 850. 1970.

380. ***T. phragmitis*** Opiz, Lotos 5:216. 1855. Holotype: An abgestorbenen Halmen von *Phragmites communis* Trin, bei der Cibulka, 26 Dec. 1852. Leg. P.M. Opiz (PR 704578!). Based on branched, septate, brown, hyphae and hyphal knots.
381. ***T. piceae*** (Funck) Pers., Traité sur les champignons comestibles, p. 59. 1818. ≡*Monilia piceae* Funck, Krypt. Gew. Fichtelgeb. Heft 22, p. 4, No. 464. 1816. =Mycelium of *Antennatula pinophila* (Nees:Fr.) Strauss, fide Hughes, New Zealand J. Bot. 8:179. 1970.
382. ***T. pinophila*** (Nees:Fr.) Chevall., Fl Gén. Env. Paris 1:34. 1826. ≡*Antennaria pinophila* Nees:Fr., Syst. Pilze, p. 279. 1816; Syst. Mycol. 3:231. 1829. ≡*Torula fuliginosa* Pers. var. *pinophila* (Nees) Pers., Mycol. Eur. 1:22. 1822. ≡*Antennaria pinophila* (Nees) Ficinus & Schubert, Fl. Dresden, ed. 2, 2:284. 1823. Nom. illeg. Art. 45.3. ICBN. ≡*Antennatula pinophila* (Nees:Fr.) F. Strauss, Flora (Beilage) 33:99. 1850. ≡*Taeniola pinophila* (Nees:Fr.) Bonord., Handb. Mykol., p. 36. 1851. ≡*Hormiscium pinophilum* (Nees:Fr.) Sacc., Syll. Fung. 4:265. 1886. ≡*Antennularia pinophila* (Nees:Fr.) Farl., Bibl. Index N. Amer. Fung. 1:223. 1905. ≡*Hormiscium pinophilum* (Nees:Fr.) Lindau, Rabenh. Krypt.-Fl. ed. 2, Band 1, Abt. VIII, pp. 597-598. 1906. Nom. illeg. Art. 45.3. ICBN. ≡*Capnophialophora pinophila* (Nees:Fr.) Borowska, Acta Mycol. 7:100. 1971. Nom. Inval. Art. 33.3. ICBN. See Hughes, New Zealand J. Bot. 8:178. 1970.
383. ***T. placentiformis*** Corda, Icon. Fung. 6:5. 1854. ≡*Oospora placentiformis* (Corda) Sacc. & Voglino, Syll. Fung. 4:20. 1886. Type: Auf *Tuber gulonum* (=*T. nigrum* Bull.) (PR). Not identifiable, fide W. Gams, *Cephalosporium*-artige Schimmelpilze (Hyphomycetes), p. 216. 1971.
384. ***T. plantaginis*** Corda, Icon. Fung. 3:5. 1839. Type: PR!. ≡*Gyrocerus plantaginis* (Corda) Sacc., Mycotheca Veneta, Cent.11, No. 1058. 1876. ≡*Taeniolella plantaginis* (Corda) S. Hughes, Canad. J. Bot. 36:817. 1958.
385. ***T. platani*** Roum. & Pat., Rev. Mycol. (Toulouse) 5:11. 1883; Fungi Sel. Gall. Exs., Cent. 24, No. 2341. 1883. **Lectotype designated herein**:Sur l'écorce morte et qui se détache, à l'hiver, du tronc des vieux plantes, Toulouse, Déc. 1881. Leg. A. Roumeguère. No. 2341 (ILL!). Isolectotypes:(FH!, L 910,254-627!, NY!). ?=*Trimmatostroma.*
386. ***T. plimmeri*** (M.J. Costantin) J.J. Weiss, J. Med. Res. 7:296. 1902. [as *plimmer*]. ≡*Saccharomyces plimmeri* M.J. Costantin, Bull. Soc. Mycol. France 17:147. 1901. ≡*Cryptococcus plimmeri* (M.J. Costantin) Neveu-Lem., Parasitologie des animaux domestiques, p. 60. 1912. ≡*Torulopsis plimmeri* (M.J. Costantin) F.P. Almeida, Ann. Fac. Med. 9:76. 1933. =*Cryptococcus neoformans* Sanfelice) Vuill., fide Lodder, The Yeasts, a Taxonomic Study, ed. 2, p. 132. 1970.
387. ***T. poikilospora*** Takah., Jap. J. Dermatol. Urol. 41:31. 1937. Type: Not seen. Excluded from *Torula* on basis of description and illustrations.
388. ***T. populina*** Peck, New York State Mus. Bull. 24:88. 1872. Holotype: On leaves of *Populus grandidentata*, Luzerne, Warren County, June. (NYS!). =*Ramularia* sp.

389. ***T. protea*** Sacc., Michelia 2:292. 1881; Myc. Ven., Cent. 16, No. 1591. Anno 1881. **Lectotype designated herein**: Padova, in culmo *Arundinis* putrescente, Sept. 1880. (PAD!). Isolectotypes: (FH!, K!). ≡*Gliomastix protea* (Sacc.) Vernona & Castella, Ann. Fac. Agrar. Univ. Pisa N.S. 5:383. 1942. Teleomorph: *Wallrothiella subiculosa* Höhn.

390. ***T. proximella*** Sacc. in Malbr. & Letendre, Bull. Soc. Amis Sci. Nat. Rouen 23:67. 1887. Holotype: Ad ligna fabrefacta. Rouen. Leg. A.F. Malbranche, Cryptogamie, Normande. (PAD!). =*Xylohypha ferruginosa* (Corda) S. Hughes.

391. ***T. pulcherrima*** Lindner, Microskopische Betriebskontrolle in den Gärungsgewerben 3 Aufl. Berlin, p. 387. 1901. ≡*Torulopsis pulcherrima* (Lindner) Sacc., Syll. Fung. 18:496. 1906. ≡*Saccharomyces* (*Torula*) *pulcherrima* (Lindner) Beij., Folia Microbiol. (Delft) 1:75. 1912. ≡*Eutorula pulcherrima* (Lindner) H. Will, Centralbl. Bakteriol., 2 Abt., 46:242. 1916. ≡*Rhodotorula pulcherrima* (Lindner) F.C. Harrison, Proc. & Trans. Roy. Soc. Canada, Ser. 3, 22(Pt. 2, Sec. 5):197. 1928. ≡*Candida pulcherrima* (Lindner) Windisch, Arch. Mikrobiol. 11:368-369. 1940. ≡*Candida pulcherrima* (Lindner) Coudert,Guide Pratique de Mycologie Médicale, p. 261. 1955. Nom. illeg. Art. 52.1. ICBN. Teleomorph: *Metschnikowia pulcherrima* Pitt & M.W. Miller,Mycologia 60:669. 1968.

392. ***T. pulchra*** Tengwall, Meded. Phytopathol. Lab. "Willie Commelin Scholten" 6:48. 1924. Type: Not located. Considered a synonym of *Sporendonema epizoum* (Corda) Cif. & Redaelli, Atti Ist. Bot. "Giovanni Briosi" Ser. 4, 5:186. 1934. =*Wallemia sebi* (Fr.:Fr.) Arx, The Genera of Fungi Sporulating in Pure Culture, p. 166. 1970.

393 ***T. pulveracea*** Corda, Icon. Fung. 2:8. 1838. Holotype: Auf rindenlosen Aesten des *Acer platanoides* im Thiergarten zu Brezina. (PR!). ≡*Oidium pulveraceum* (Corda) Rivolta, Dei parassiti vegetali, p. 440. 1873. ≡*Oospora pulveracea* (Corda) Sacc. & Voglino in Sacc. Syll. Fung. 4:24. 1886. =*Xylohypha nigrescens* (Pers.:Fr.) Mason in Deighton. See Hughes Canad. J. Bot. 36:825.1958.

394. ***T. pulvillus*** Berk. & Broome, Ann. Mag. Nat. Hist. Ser. 2, 5:460. 1850. Holotype: On dead twigs of oak; bursting in little tufts through the bark, Apethorpe, Great Britain, March 1841. (K!). ≡*Taeniolella pulvillus* (Berk. & Broome) M.B. Ellis, More Dematiaceous Hyphomycetes, p. 57. 1976.

395. ***T. pulvinata*** Speg., Anales Soc. Ci. Argent. 10:164. 1880. Holotype: In fibris interioribus trunci vetusti putrescentis *Pircuniae dioicae* prope el Bagnado de San José de Flores, Jul. 1880. (LPS 12.751!). ≡*Torula spegazzinii* Sacc., Syll. Fung. 15:417. 1901. Nom. illeg. Art. 52.1. ICBN. =*Torula herbarum* (Pers.) Link:Fr. fide Joly, Bull. Soc. Mycol. France 80:187-192. 1964.

396. ***T. pulvinata*** (Farl.) Farl., Bull. U.S. Fish Commiss. 6:2. 1886. Nom. illeg. Art. 53.1. ICBN. ≡*Oidium pulvinatum* Farl., Rev. Mycol. (Toulouse) 6:198. 1884. Holotype: On salt cod fish, [*Gadus morhua*], Gloucester, Massachusetts, Prof. Hyatt. (FH!). ≡*Oidium morrhuae* Farl., Bull. U.S. Fish Commiss. 6:4. 1886. A Nom. nov. for *O. pulvinatum* Farl. Non Berkeley & Curtis in Berkeley, 1875. ≡*T. morrhuae* (Farl.) Sacc. in Trotter, Syll. Fung. 25:762. 1931. =*Wallemia sebi* (Fr.:Fr.) Arx.

397. ***T. pulvinata*** (Bonord.) Sacc., Syll. Fung. 4:253. 1886. Nom. illeg. Art. 53.1. ICBN. =*Alysidium pulvinatum* Bonord., Abh. Mykol. 1:86. 1864. Type: Not located. An acervular fungus, not a *Torula*!
398. ***T. pulviniformis*** H. & P. Syd., Ann. Mycol. 4:345. 1906. Holotype: In foliis putridis Bromeliaceae cujusdam, São Leopoldo, Prov. Río Grande do Sul Brasiliae. 1905, Leg. J. Rick. (S!). =*Coniosporium diversum* (Cooke) J.L. Crane & Schokn.
399. ***T. punctata*** Richon, Cat. Champ. Marne, p. 436. 1889. Type: Not located. Not a *Torula*.
400. ***T. quaternata*** Berk. & M.A. Curtis, Grevillea 3:14. 1874. Holotype: On leaves of *Dasylirion graminifolium*, Wright No. 3768, (K!), Authentic Material: Blanco Bottom, Texas, July 1851, Wright No. 18, (FH!) ≡*Tretospora quaternata* Berk. & M.A. Curtis) J.L. Crane & Schokn., Canad. J. Bot. 62:1097. 1984.
401. ***T. quercina*** Opiz, Lotos 5:216. 1855. Holotype: Bohemia centralis, Praha-Stromovka, 10 Nov. 1854. (PR 704579!). =*Trimmatostroma betulinum* (Corda) S. Hughes.
402. ***T. raffinosa*** F.C. Harrison, Proc. & Trans. Roy. Soc. Canada, Ser. 3, 21(Pt. 2, Sec. 5):371. 1927. =Blastomycete.
403. ***T. ramalinae*** Nyl. in Roum., Fungi Sel. Gall. Exs., Cent. 42, No. 4188. Anno 1887. Nom. inval. Art. 34.1. ICBN. **Lectotype designated herein**: No. 4188. (ILL!). Brown, septate mycelium on a thallus. Not identifiable, fide Hawksworth, Bull. Brit. Mus. Nat. Hist., Bot. 6:288. 1979.
404. ***T. ramosa*** Fuckel, Symb. Mycol., p. 348. 1870. **Lectotype designated herein**: Ad *Salicis* truncos putridos. Raro Vere-Münchau prope Hattenheim, Fungi Rhen. Exs. Suppl., Fas. 5, No. 1908. Anno 1867. (G!), Isolectotypes examined: (B!, FH!, L!, NY!). =*Alysidium resinae* (Fr.:Fr.) M.B. Ellis, Dematiaceous Hyphomycetes, p. 90. 1971.
405. ***T. ramosa*** Peck, Annual Rep. New York State Mus. 32:39. 1879. Nom. illeg. Art. 53.1. ICBN. Non Fuckel 1870. ≡*Torula peckii* Sacc. & P. Syd., Syll. Fung. 4:1070. 1899. Holotype: Decaying pine wood, North Greenbush, Sept., (NYS!). =*Alysidium resinae* (Fr.) M.B. Ellis, Dematiaceous Hyphomycetes, p. 90. 1971.
406. ***T. ramosa*** Saito, Jap. J. Bot. 1:49. 1922. Nom. illeg. Art. 53.1. ICBN. =Blastomycete.
407. ***T. reptans*** Corda, Icon. Fung. 1:8. 1837. Type: (PR). Not seen. ?=*Taeniolella stilbospora* (Corda) S. Hughes, Canad. J. Bot. 36:817. 1958.
408. ***T. resinae*** G. Lindau, Rabenh. Krypt.-Fl., ed. 2, Band 1, Abt. VIII, p. 578. 1906. Holotype: Auf Fichtenharz bei Chamonix (Jaap), 22 Juli, 1905. (B!). ≡*Helicoma resinae* (Lindau) J.L. Crane & Schokn., Mycologia 67:669. 1975.
409. ***T. resinicola*** Peyronel, Mem. Reale Accad. Sci. Torino, Ser. 2, 66:42. 1915. Hab.: In plagis resina obductis ramorum *Laricis decidue* dejectorum: Riclaretto (locis dictis La Tiriero, 1400 m. alt. et La Figliolo, 1500 m alt.) in Vallibus Valdensibus Pedemontii, Ital. bor. Jan.-Febr. 1913, B. Peyronel. Type: Not located.
410. ***T. rhizophila*** Corda, Icon. Fung 1:8. 1837. ≡*Hormiscium rhizophilum* (Corda) Bonord., Handb. Mykol., p. 33. 1851. Type: Not located. Not identifiable from the description and illustration, Tab. 2, Fig. 127.

411. ***T. rhizophila*** Corda forma ***agropyri-repentis*** Thüm., Myc. Univ., Cent. II, No. 191. Anno 1875. Nom. nud. Art. 32.1. ICBN.: Bohemia: Königswald in rhizomis aridis *Agropyri repentis*, raro, Aut. 1873, Thümen. **Lectotype designated herein:** (ILL!). Isolectotypes: (FH!, L 910,254-628!, PR 77279!). =*Arthrinium phaeospermum* (Corda) M.B. Ellis.

412. ***T. rhizophila*** Corda subsp. ***taraxaci*** Lambotte in Sacc., Syll. Fung. 4:259. 1886. Erroneously attributed to Desmazières by Sacc., Syll. Fung. 12:786. 1897.Type: Not located.

413. ***T. rhizophila*** Corda var. ***arundinacea*** Westend. in Westend. & Wallays, Herb. Crypt., Fasc. 24, No. 1197. Anno. 1855. Nom. nud. Art. 32.1. ICBN. **Lectotype designated herein**: Sur les rhizomes exondées [excoriées] de *l'Arundo phragmites*, dans les fossés des prairies le long de la Lys, à Courtrai [Kortrijk, Belgium]. (B!), Isolectotype: (K!). =*Arthrinium phaeospermum* (Corda) M.B. Ellis.

414. ***T. rhododendri*** Kunze in Corda:Fr. in Sturm's Deutschl. Fl. III (Pilze), Bd. 2, Hefte 8:95. 1829; Syst. Mycol. 3:503. 1832. Lectotype: '*Torula rhododendri* mihi in *Rh. ferrugineo* [scr Kunze]. *Torula rhododendri* Kz [scr. Ehrenberg]'. (B!). ≡*Antennularia rhododendri* (Kunze) Höhn., Sitzungsber. Kaiserl. Akad. Wiss., Math.-Naturwiss. Cl., Abt. I, 118:1493. 1909. ≡*Capnocheirides rhododendri* (Kunze in Corda:Fr.) J.L. Crane & S. Hughes, Mycologia 74:753. 1982.

415. ***T. rhombica*** V.G. Rao & de Hoog, Persoonia 8:199. 1975. Holotype: In ligno putrido, in seminario arborum Balaji, Hyderabad, Andhra Pradesh, India. Sept. 1969. Leg. V.G. Rao, (IMI 162.901!). Isotype: (CBS 77). =*Bahusandhika*.

416. ***T. ribis*** R. Ludwig, Bull. Soc. Bot. Genève Ser. 2, 11:447, Fig. 23-25, 460, Fig. 2. 1917. ≡*Torulopsis ribis* (R. Ludwig) Saccardo, Syll. Fung. 25:632. 1931. = Blastomycete.

417. ***T. robiniae*** Allesch., Ber. Naturwiss. Vereins Landshut. 12:105. 1892. Holotype: Auf der inneren Seite faulender Rinde von *Robinia pseudacacia*. München: auf einem Holzlagerplatze 21.2.84, Leg. Allescher. (M!). =*Thielaviopsis basicola* (Berk. & Broome) Ferraris.

418. ***T. rosacea*** Van Hest, Centralbl. Bakteriol. Abt. 2, 18:780, Pl. 1, Fig. B, Pl. 3, Figs. 5-6. 1907. ≡*Torulopsis rosacea* (Van Hast) Sacc. & Trotter, Syll. Fung. 22:1239. 1913. =Blastomycete.

419. ***T. rosea*** Preuss, Sturm'sDeutschl. Fl. III (Pilze), Bd. 6:13. 1848; Linnaea. 24:105. 1851. ≡*Oospora rosea* (Preuss) Sacc. & Voglino in Sacc., Syll. Fung. 4:18. 1886. **Lectotype designated herein**: Auf morschen Rosenzweigen, 1845. Klotzschii Herb. Vivum Myc. Fung. ed. I, Cent. 13, No. 1267. Anno 1849. (B!). Isolectotypes: (FH!, M!, PR 277285!). =*Gliocladium roseum* (Link) Bainier, fide W. Gams, *Cephalosporium*-artige Schimmelpilze (Hyphomycetes), p. 217. 1971.

420. ***T. rosea*** Sacc., Nuovo Giorn. Bot. Ital. 8:190. 1876. Nom. illeg. Art. 53.1. ICBN. Non Preuss, 1851. Holotype: In ramis corticatis *Populi nigrae* a Selva (Treviso), Aug. 1875. (PAD, Not seen). ≡*Oospora subrosea* (Sacc.) Sacc. & Voglino in Sacc., Syll. Fung. 4:18. 1886. Not identifiable fide Gams, *Cephalosporium*-artige Schimmelpilze (Hyphomycetes), p. 218. 1971.

421. ***T. rosea*** Harden, name attributed to Harden by F.C. Harrison, Proc. & Trans. Roy. Soc. Canada, Ser. 3, 22(Pt. 2, Sec. 5):192. 1928. Nom. nud. Art. 32.1. ICBN. A possible synonym of *Rhodotorula rubra* (Demme) Lodder.
422. ***T. rostella*** F.C. Harrison, Proc. & Trans. Roy. Soc. Canada, Ser. 3, 21(Pt. 2, Sec. 5):358. 1927. =Blastomycete.
423. ***T. rostrata*** F.C. Harrison, Proc. & Trans. Roy. Soc. Canada, Ser. 3, 21(Pt. 2, Sec. 5):364. 1927. =Blastomycete.
424. ***T. rubefaciens*** J. Grosbüsch, Centralbl. Bakteriol., 2 Abt., 42:638. 1915. =*Candida pulcherrima* (Lindner) Windisch. Teleomorph: *Metschnikowia pulcherrima* Pitt & M.W. Mill. fide Lodder, The Yeasts, a Taxonomic Study, ed. 2, p. 418. 1970.
425. ***T. rubefaciens*** Szilvinyi, Zentralbl. Bakteriol., 2 Abt., 103:180. 1941. Nom. illeg. Art 53.1. ICBN. Type: Not located. Not identifiable from original description.
426. ***T. rubella*** Bonord. in Rabenh., Fungi Europaei ed. 3, Cent. 3, No. 281. Anno 1860; Bot. Zeitung (Berlin) 19:195. 1861. ≡*Oidium rubellum* (Bonord.) Sacc. & Voglino in Sacc., Syll. Fung. 4:46. 1886. Syntypes: In foliis vivis Graminum in Guestphalia. F. E. No. 281. (L 910,236-127!, B!) Material from Roum., Fungi Gall. Exs. No. 1696 as *T. rubella* Bonord. is from Exs. No. 281.
427. ***T. rubeo-alba*** Preuss, Linnaea. 25:74. 1852. Holotype: Auf Saft von *Sambucus*. (B). ≡*Oospora rubeo-alba* (Preuss) Sacc. & Voglino in Sacc. Syll. Fung. 4:19. 1886. =*Chrysosporium* sp., fide Gams, *Cephaloporium*-artige Schimmelpilze (Hyphomycetes), p. 217. 1971.
428. ***T. rubescens*** Saito, Jap. J. Bot. 1:47. 1922. ≡*Mycotorula rubescens* (Saito) Cif. & Redaelli, Atti Ist. Bot. Univ. Pavia, Ser. 3, 2:264. 1925. ≡*Rhodotorula rubescens*(Saito) F.C. Harrison, Proc. & Trans. Roy. Soc. Canada, Ser. 3, 22(Pt. 2, Sec.5):194. 1928. ≡*Rhodotorula glutinis* (Fresen.) F.C. Harrison var. *rubescens* (Saito) Lodder, Verh. Kon. Ned. Akad. Wetensch., Afd. Natuurk., Tweede Section 32:86. 1934. ≡*Rhodotorula glutinis* (Fresen.) F.C. Harrison var. *rubescens* (Saito) Coudert, Guide Pratique de Mycologie Médicale, p. 269.1955. Nom. illeg. Art. 52.1. ICBN. =*Rhodotorula glutinis* (Fresen.) F.C. Harrison fide Fell, Tallman & Ahearn in Rij, The Yeasts, a Taxonomic Study, ed. 3, p. 897. 1984. Teleomorph: *Rhodosporidium toruloides* Banno fide Fell & Statzell-Tallman in Kurtzman & Fell, The Yeasts, a Taxonomic Study, ed. 4, p. 690. 1998.
429. ***T. rubi*** R. Ludwig, Bull. Soc. Bot. Genève, Ser. 2, 11:448, Fig. 26-28, 460, Fig. 1. 1917. ≡*Torulopsis rubi* (R. Ludwig) Saccardo, Syll. Fung. 25:632. 1931. =Blastomycete.
430. ***T. rubiginosa*** Rivolta, Dei parassiti vegetali, come introduzione albo studie delle malattie parassitarie e delle alterazioni dell' alimento degli animali domestici, Torino, p. 438. 1873. Type: Not preserved. ≡*Oospora rubiginosa* (Rivolta) Sacc., Syll. Fung. 10:514. 1892. =*Sporendonema epizoum* (Corda) Cif. & Redaelli, Atti Ist. Bot. "Giovanni Briosi", Ser. 4, 5:186. 1934. Probably *Scopulariopsis brevicaulis* (Sacc.) Bainier, fide W. Gams, *Cephalosporium*-artige Schimmelpilze (Hyphomycetes), p. 217. 1971.

See Errata

431. ***T rubi-idaei*** Allesch., Ber. Naturwiss. Vereins Landshut 12:106. 1892. Holotype: Auf faulenden Stengeln von *Rubus idaeus*, Um München, bei Sendling, 20.12.83, Leg. Schnabl. (M!). =*Torula herbarum* (Pers.) Link:Fr.

432. ***T. rubra*** Schimon in H. Will, Centralbl. Bakteriol., 2 Abt., 35:114. 1912. ≡*Torulopsis saitoi* Cif. & Redaelli, Atti Ist. Bot. Univ. Pavia, Ser. 3, 2:236. 1925. Nom. illeg. Art. 52.1. ICBN. =*Rhodotorula glutinis* (Fresen.) F.C. Harrison var. *glutinis*, fide J. Lodder, The Yeasts, a Taxonomic Study, ed. 2, p. 1198. 1970. =*Rhodotorula glutinis* var. *dairenensis* Hasegawa & Banno fide Fell & Statzell-Tallman in Kurtzman & Fell, The Yeasts, a Taxonomic Study, ed. 4, p. 814. 1998.

433. ***T. rubra*** Schimon in Will var. ***alpha*** Saito, Jap. J. Bot. 1:48. 1922. Nom. Inval. Art. 34.1. ICBN. =*Rhodotorula glutinis* var. *dairenensis* Hasegawa & Banno fide Fell & Statzell-Tallman in Kurtzman & Fell, The Yeasts, a Taxonomic Study, ed. 4, p. 814. 1998.

434. ***T. rufescens*** Fresen., Beitrage zur Mykologie, p. 86. 1863. Type: Not located. ≡*Oospora rufescens* (Fresen.) Sacc., Syll. Fung. 10:514. 1892. =*Sporendonema epizoum* (Corda) Ciferri & Redaelli, Atti Ist. Bot. "Giovanni Briosi", Ser. 4, 5:186. 1934. =*Wallemia sebi* (Fr.:Fr.) Arx.

435. ***T. rufula*** Saito, Jap. J. Bot. 1:46. 1922. =*Torulopsis rufula* (Saito) Cif. & Redaelli, Atti Ist. Bot. Univ. Pavia, Ser. 3, 2:259. 1925. ≡*Rhodotorula rufula* (Saito) F.C. Harrison, Proc. & Trans. Roy. Soc. Canada, Ser. 3, 22(Pt. 1, Sec. 5):198. 1928. =*Rhodotorula glutinis* (Fresen.) F.C. Harrison var. *glutinis*, fide Lodder, The Yeasts, a Taxonomic Study, ed. 2, p. 1195. 1970.

436. ***T. rugosa*** Saito, Jap. J. Bot. 1:49. 1922. ≡*Mycotorula rugosa* (Saito) F.C. Harrison, Proc. & Trans. Roy. Soc. Canada, Ser. 3, 22(Pt. 1, Sec. 5):215. 1928. Material preserved at CBS does not resemble Saito's description, fide Lodder, Verh. Kon. Ned. Akad. Wetensch., Afd. Natuurk., Tweede Section 32:1-256. 1934.

437. ***T. rugosa*** F.C. Harrison, Proc. & Trans. Roy. Soc. Canada, Ser. 3, 21(Pt. 2, Sec. 5):366. 1927. Nom. illeg. Art. 53.1. ICBN. =Blastomycete.

438. ***T. sacchari*** Corda, Icon. Fung. 4:23. 1840. Type: Not located. =*Sporendonema epizoum* (Corda) Ciferri & Redaelli, Atti Ist. Bot. "Giovanni Briosi" Ser. 4, 5:185. 1934. =*Wallemia sebi* (Fr.:Fr.) Arx.

439. ***T. sacchari-lactis*** Oudem., Ned. kruidk. Arch. Sect. 2, 6:297. 1894. Type: L 910,254-629!. [No material in packet, identity of species is uncertain.]

440. ***T. saccharina*** Heald & W. Pool, Annual Rep. Nebraska Agric. Exp. Sta. 21:54-68. 1908. Type: Not located. =*Sporendonema epizoum* (Corda) Cif. & Redaelli, Atti. Ist. Bot. "Giovanni Briosi", Ser. 4, 5:186. 1934. =*Wallemia sebi* (Fr.:Fr.) Arx.

441. ***T. saccharosa*** F.C. Harrison, Proc. & Trans. Roy. Soc. Canada, Ser. 3, 21(Pt. 2, Sec. 5):367. 1927. =Blastomycete.

442. ***T. sakuranei*** (Beurmann & Gougerot) Coudert, Guide Pratique de Mycologie Médicale, p. 275. 1955. [as (Gourgerot)]. ≡*Zymonema sakuranei* Beurmann & Gougerot, Bull. & Mém. Soc. Méd. Hôp. Paris. Sér. 3, 18:238. 1909. =*Dermatium sakuranei* C.W. Dodge, Medical Mycology, p. 679. 1935. [as (Jannin) Dodge]. Several other names that appear to be facultative synonyms are also reported by Dodge.

443. ***T. salicis*** Fuckel, Hedwigia 5:30. 1866; Fungi Rhen. Exs. Suppl. Fasc. 2, No. 1622. Anno 1866. **Lectotype designated herein**: Ad *Salicis capreae* ramulos aridos. In sylva Hostrichensi. No. 1622. (G!) Isolectotypes: (K!, L!). =*Taeniolella stilbospora* (Corda) S. Hughes.

444. ***T. sambuci*** Fuckel, Symb. Mycol. Nachtr 2:77. 1873. **Lectotype designated herein**: Fungi Rhen. Exs. Suppl. Fasc. 26, No. 2585. Anno 1873. (G!). Isolectotypes: (B!, FH!, L!). =*Apiospora montagnei* P.A. Saccardo. Anamorph: *Arthrinium*.

445. ***T. sambuci*** R. Ludw. Bull. Soc. Bot. Genève Ser. 2, 11:441, Figs. 9-11, 460, Fig. 1. 1917. Nom. illeg. Art. 53.1. ICBN. ≡*Torulopsis sambuci* R. Ludw. ex Sacc. in Trotter, Syll. Fung. 25:632. 1931.

446. ***T. sambuci*** Fuckel forma *minor* Brunaud, Bull. Soc. Sci. Nat. Ouest France, Sér 1, 4(1):38. 1894. Type: Not located. Not identifiable from description.

447. ***T. sanfelice*** J. Weis, J. Med. Res. 7:294. 1902. ≡*Saccharomyces lithogenes* Sanfelice, Centralbl. Bakteriol. 1 Abt. Originale 18:521-526. 1895. ≡*Cryptococcus lithogenes* (Sanfelice) Vuill., Rev. Gen. Sci. 12:740-741. 1901. =*Cryptococcus neoformans* (Sanfelice) Vuill. fide Lodder, The Yeasts, a Taxonomic Study, ed. 2, p. 1132. 1970.

448. ***T. sanguinea*** O. Schimon in H. Will., Zentralbl. Bakteriol., 2 Abt., 35:114. 1912. ≡*Torulopsis sanguinea* (O. Schimon) Cif. & Redaelli, Atti Ist. Bot. Univ. Pavia Ser. 3, 2:238. 1925. ≡*Rhodotorula sanguinea* (O. Schimon) F.C. Harrison, Proc. & Trans. Roy. Soc. Canada, Ser. 3, 22(Pt. 2, Sec. 5):192. 1928. ≡*Rhodotorula mucilaginosa* R. Ciferri & Redaelli var. *sanguinea* (O. Schimon) Lodder, Verh. Kon. Ned. Akad. Wetensch., Afd. Natuurk., Tweede Section 32:75. 1934. =*Rhodotorula rubra* (R. Demme), Lodder, The Yeasts, a Taxonomic Study, ed. 2, p. 1215. 1970. =*Rhodotorula mucilaginosa* (Jörg.) F.C. Harrison fide Fell & Statzell-Tallman in Kurtzman & Fell, The Yeasts, a Taxonomic Study, ed. 4, p. 820. 1998.

449. ***T. schoenii*** Roukhelman, Compt. Rend. Séances Soc. Biol. Fil. 124:547. 1937. Nom. nud. Art. 32.1. ICBN; Ann. Ferment. 3:149-155. 1937. Nom. Inval. Art. 36.1. ICBN. =*Aureobasidium pullulans* (de Bary) G. Arnaud, fide W.B. Cooke, Mycopathol. Mycol. Appl. 17:27. 1962. =*Aureobasidium pullulans* (de Bary) G. Arnaud var. *pullulans* , fide de Hoog, Stud. Mycol. 15:158. 1977.

450. ***T. sebi*** Fr., falsely so cited in R. Ciferri, Manuale di Micologia Medica 1:180. 1958. Ciferri suggests that *Torula sebi* Fr. may be an earlier name for *Torula epizoa* Corda. 1829. =*Wallemia sebi* (Fr.:Fr.) Arx.

451. ***T. securinegae*** Thüm., Rev. Mycol. (Paris) 1:11. 1879; Thüm, Fungi Exot., Dec. 1, No. 9. 1879. Type: Insula Borbonia [as Bourbonia]: Ad *Securinegae nitidae* Willd. folia viva, Leg. Com. Dr. C. Keck. Fungi Exot., Dec. 1, No. 9. Not located. Not identifiable from the description.

452. ***T. septonema*** Preuss, Linnaea 25:726. 1852. Type: Not located. Authentic material: Hoyerswerdae ad cortices, vere 1853, Leg. Preuss, in Klotzschii Herb. Vivum Myc. Fung., ed. I, Cent. 19, No. 1891. Anno 1854. (FH!, PR 777286!). The material contains chains of branched, septate brown cells and occasional chains of two-celled brown conidia. Not a *Torula*.

453. ***T. sepulta*** Ellis & Barthol., J. Mycol. 8:177. 1902. **Lectotype designated herein:** Pine post below surface of ground, Rockport, Rooks County, Kansas, April 16, 1901, Leg. E. Bartholomew, No. 2844, (FH!). =*Bispora betulina* (Corda) S. Hughes.

454. ***T. shibatana*** Okun., Jap. J. Bot. 5:320. 1931. ≡*Sporobolomyces shibatanus* (Okun.) Verona & Ciferri, Atti. Ist. Bot. "Giovanni Briosi", Ser. 4, 10:246. 1938. =*Sporobolomyces pararoseus* H.C. Olson & B.W. Hammer, fide Lodder & Kreger, The Yeasts, a Taxonomic Study, ed. 1, p. 358. 1952. Nom. nud. Art. 32.1. ICBN. Teleomorph: *Sporidiobolus pararoseus* Fell & Tallman fide Fell & Tallman in Kreger, The Yeasts, a Taxonomic Study, ed. 3, p. 535. 1984.

455. ***T. silvatica*** Dasz., Bull. Soc. Bot. Genève, Ser. 2, 4:289-290. 1912. =Blastomycete.

456. ***T. simiellisii*** Vasant Rao, K.A. Reddy & V. Subba Rao, Geobios 5:219-220. 1978. Holotype: On unidentified stems, leaves (*Sansevieria* sp.), Mananoor Forest, Dt. Mahaboobnagar, A.P., India, Oct. 1976, Leg. VSR, VMRL No. 4!. =*Coniosporium diversum* (Cooke) J.L. Crane & Schokn.

457. ***T. simplex*** (Lindner) Sacc., Syll. Fung. 22(2):1345. 1913. ≡*Penicillium simplex* Lindner, Atlas mikroskopischen Grundlagen der Gärungskunde Taf. 36. 1903. ≡*Scopulariopsis simplex* (Lindner) Vuill., Bull. Soc. Mycol. France 27:143. 1911. =*Sporendonema epizoum* (Corda) Cif. & Redaelli, fide F.J. Morton & G. Smith, Mycol. Pap. I.M.I. 86:89. 1963. =*Wallemia sebi* (Fr.:Fr.) Arx.

458. ***T. soleirolii*** Duby, Bot. Gall. Pars secunda, p. 931. 1830. **Lectotype designated herein**: In Corsica circa Calvi in *Cisto salvifolio* (STR!), Isolectotype: (UPS!). =*Antennaria cistophila* Fr.:Fr., Syst. Mycol. 3(Index):190. 1832. =Hyphae of *Antennulariella* sp., fide Hughes, Mycologia 68:745. 1976.

459. ***T. sparsa*** (Link) Fr.:Fr., Syst. Mycol. 3:(Index):119. 1832. ≡*Monilia sparsa* Link in Willd. Sp. Pl. IV, 6(1):127. 1824. Presumed type: (B!). =*Coelosporium fructiculosum* Link in Willd. Sp. Pl. IV, 6(1):46. 1824, fide Hughes, Canad. J. Bot. 36:753. 1958.

460. ***T. sparsa*** Berk. & M.A. Curtis, Grevillea 3:15. 1874. Nom. illeg. Art. 53.1. ICBN. Holotype: On old pine wood, Car. Inf. No. 1477. (K!). =*Cladosporium herbarum* (Pers.) Link:Fr.

461. ***T. spegazzinii*** Sacc., Syll. Fung. 15:417. 1901. Nom. illeg. Art. 52.1. ICBN. ≡*Torula pulvinata* C.L. Spegazinni. =*Torula herbarum* (Pers.) Link:Fr.

462. ***T. sphaerella*** Cooke, Grevillea 9:11. 1880. Holotype: On leaves of *Coffea arabica*, Venezuela, Leg. Dr. Ernst (K!). The spores are clumped in a mucous(?) or in insect feces(?), light brown, 5- to 6-phragmoseptate, and appear to lack an attachment point.

463. ***T. sphaeriaeformis*** (Berk. & Broome) Cooke & Ellis, Grevillea 7(42):38. 1878. ≡*T. abbreviata* Corda var. *sphaeriaeformis* Berk. & Br.

464. ***T. sphaeriaeformis*** (Berk. & Broome) Saccardo. Syll. Fung. 15:417. 1901. Nom. illeg. Art. 52.1. ICBN. ≡*T. abbreviata* Corda var. *sphaeriaeformis* Berk. & Br.

465. ***T. sphaerica*** B.W. Hammer & Cordes, Iowa Agric. Exp. Sta. Res. Bull. 61:14. 1920. ≡*Torulopsis sphaerica* (B.W. Hammer & Cordes) Lodder, Verh. Kon. Ned. Akad. Wetensch., Afd. Natuurk., Tweede Section 2, 32:141. 1934. ≡*Cryptococcus sphaericus* (Hammer & Cordes) K.W. Anderson & C.E. Skinner, Mycologia 39:169. 1947. ≡*Candida sphaerica* (B.W. Hammer & Cordes) Meyer & Yarrow, Int. J. Syst. Bacteriol. 28:614. 1978. Teleomorph: *Kluyveromyces lactis* (Dombr.) Van der Walt. fide Lachance in Kurtzman & Fell, The Yeasts, a Taxonomic Study, ed. 4, p. 233. 1998.

466. ***T. splendens*** Cooke, Grevillea 3:178. 1875. Holotype: On bark. Forres. Leg. Rev. J. Keith. (K). ≡*Hormiscium splendens* (Cooke) Sacc., Syll. Fung. 4:264. 1886. Based on metacapnodiaceous hyphae with occasional *Capnobotrys* fructifications, fide Hughes, Mycologia 68:787. 1976.

467. ***T. spongicola*** Dufour, Bull. Soc. Vaud. Sci. Nat. Ser. 2, 18:144-146. 1882. Type:Not located. Conidia described as rounded to oval, measuring 4 to 7 mm.

468. ***T. sporendonema*** Berk. & Broome, Ann. Mag. Nat. Hist. Ser. 2, 5:460. 1850. A Nom. nov. for *Sporendonema casei* Desm., Ann. Sci. Nat. 11:246-249. 1827. Non *Torula casei* Corda. Type not located. ≡*Sporendonema casei* Desm., fide Sigler & J.W. Carmich., Mycotaxon 4:404-407. 1976.

469. ***T. (Trachytora) sporodesmoides*** Ellis & Everh., Proc. Acad. Nat. Sci. Philadelphia 1894:377. 1894. Holotype: On bark, Pasadena [California], January 1894, Leg. Prof. A.J. McClatchie No. 622. (NY!). =*Trimmatostroma betulinum* (Corda) S. Hughes.

470. ***T. spumosa*** F.C. Harrison, Proc. & Trans. Roy. Soc. Canada, Ser. 3, 21(Pt. 2, Sec. 5):374. 1927. =Blastomycete.

471. ***T. stilbospora*** Corda, Sturm's, Deutschl. Flora III (Pilze), Bd. 2, Hefte 8:99. 1829. Type: (PR). ≡*Hormiscium stilbosporum* (Corda) Sacc., Syll. Fung. 4:264. 1886. ≡*Taeniolella stilbospora* (Corda) S. Hughes, Canad. J. Bot. 36:817. 1958.

472. ***T. stilbospora*** Corda forma ***capraeae*** Thüm., Myc. Univ., Cent. 12, No. 1180. 1878. Nom. nud. Art. 32.1. ICBN. **Lectotype designated herein**: Bavaria: Bayreuth ad ramulos emortuos adhuc. pendulos *Salicis, capraeae* Lin., Apr. 1875, Leg. Thümen, Myc. Univ. No. 1180. (FH!) solectotypes: (ILL!, L 910.250-616!, NY!) =*Trimmatostroma betulinum* (Corda) S. Hughes.

473. ***T. stilbospora*** Corda forma ***corticis*** Roum., Fungi Sel. Gall. Exs. Cent. 66, No. 6547. 1894; Rev. Mycol. (Paris) 16:112. 1894. **Lectotype designated herein**: Sur écorce de *Salix capraea*, Sept. 1894, Leg. F. Fautrey, F. S. G.E. No. 6547. 1894. (ILL!). =*Taeniolella stilbospora* (Corda) S. Hughes.

474. ***T. subacida*** F.C. Harrison, Proc. & Trans. Roy. Soc. Canada, Ser. 3, 21(Pt. 2, Sec. 5):355. 1927. =Blastomycete.

475. ***T. subramosa*** (Link) Sacc., Syll. Fung. 4:249. 1886. ≡*Oidium subramosum* Link. in Willd., Sp. Pl. IV, 6(1):125. 1824. Type: (L). ≡*Oospora subramosa* (Link) Wallr., Fl. Crypt. Germ., p. 183. 1833. ≡*Conoplea fusca* Pers., fide S. Hughes, Canad. J. Bot. 36:755. 1958.

476. ***T. suganii*** Okun., Jap. J. Bot. 5:318. 1931. ≡*Rhodotorula suganii* (Okun.) Lodder, Verh. Kon. Ned. Akad. Wetensch., Afd. Natuurk., Tweede Section

32:120. 1934. =*Rhodotorula glutinis* (Fresen.) F.C. Harrison var. *glutinis* , fide Lodder, The Yeasts, a Taxonomic Study, ed. 2, p. 1194. 1970.

477. ***T. sulphurea*** Preuss, Linnaea 25:725. 1852. Holotype: Auf faulendem Mehl. Herb. C.G.T. Preuss (B). ≡*Oospora sulphurea* (Preuss) Sacc. & Voglino, Syll. Fung. 4:21. 1886. =*Oidiodendron* sp., fide W. Gams, *Cephalosporium*-artige Schimmelpilze (Hyphomyetes), p. 219. 1971.
478. ***T. taiwanensis*** T. Baba, Bull. School Agric. Taihoku Imp. Univ. 4:1-7. 1943. Nom. Inval. Art. 36.1. ICBN. =Blastomycete.
479. ***T. taraxaci*** (Lambotte in Sacc.) Sacc., Syll. Fung. 15:417. 1901. See *T. rhizophila* Corda subsp. *taraxaci* Lambotte in Sacc.
480. ***T. telae*** (Sacc.) Sacc., Syll. Fung. 15:417. 1901. ≡*T. expansa* (Kunze) Pers.:Fr. var. *telae* Sacc., Syll. Fung. 4:256. 1886.
481. ***T. teloe*** Therry in Roum., Fungi Sel. Gall. Exs. Cent. 55, No. 5498. Anno 1890; Rev. Mycol. (Paris) 12:169. 1890. **Lectotype designated herein**: Sur toile pourrissante d'un vieux sac abandonné au Parc de la Tête-d'Or (Lyon), Décembre 1887, Leg. J. Therry, F.S.G.E. No. 5498. (ILL!). Isolectotypes: (B!, FH!, K!). =*Torula herbarum* (Pers.) Link: Fr.
482. ***T. tenera*** Link, Mag. Ges. Naturf. Freunde, Berlin 7:40. 1816. Holotype: (B!). =*Xylohypha nigrescens* (Pers.:Fr.) Mason in Deighton, Mycol. Pap. I.M.I. 78:43. 1960.
483. ***T. tenerrima*** Preuss, Linnaea 24:104. 1851. ≡*Oospora tenerrima* (Preuss) Sacc. & Voglino, Syll. Fung. 4:13. 1886. **Lectotype designated herein**: In trabibus ubi Natrum carbonicum illitum. Leg. Preuss, Klotzschii Herb. Vivum Myc. Fung. ed. I, Cent. 18, No. 1766. Anno 1853. (B!). Isolectotype: (PR 777332!). An Actinomycete, possibly a *Streptomyces*, fide W. Gams, *Cephalosporium*-artige Schimmelpilze (Hyphomycetes), p. 219. 1971.
484. ***T. tenuissima*** Corda, Icon. Fung. 1:18. 1837. Holotype: (PR 155700!); Isotype:(DAOM 49841!). ≡*Hormiscium tenuissimum* (Corda) Bonord., Handb. Allg. Myk., p. 33. 1851. =*Torula herbarum* (Pers.) Link:Fr.
485. ***T. terrestris*** Misa, Canad. J. Bot. 45:367. 1967. Holotype: Isolated from a sal forest soil. Gorakhpur, U.P., India, Nov. 1961, Leg. P.C. Misra. Comm. 8.7.62. (IMI 93988!).
486. ***T. tetrameria*** Preuss, Linnaea 24:104. 1851. Type: In cortice *Populi tremulae.* Pinka pr. Hoyerswerda. Not located. Not identifiable from the description.
487. ***T. thermantitonum*** (G. Johnson) Guilliern. & F.W. Tanner in Guilliermond, The Yeasts, [Translated and thoroughly revised by F.W. Tanner in collaboration with the original author].; John Wiley & Sons, New York, p. 304. 1920. ≡*Saccharomyces thermantitorum* G. Johnson, J. Inst. Brew. 11:466. 1905. =*Saccharomyces cervisiae* Meyen ex E.C. Hansen, fide Vaughan-Martini & Martini in Kurtzman & Fell, The Yeasts, a Taxonomic Study, ed. 4, p. 361. 1998.
488. ***T. thermophila*** Cooney & R. Emers., Thermophilic Fungi, p. 92. 1964. Holotype: On straw litter from a chicken nest, Reno, Washoe County, Nevada, Strain No. 3, Dec. 1961, D.G. Cooney & R. Emerson. (UC 1206525!). ≡*Scytalidium thermophilum* (Cooney & R. Emers.) Austwick, New Zealand J. Agr. Res. 19:29. 1976.

489. ***T. tingitana*** Pat., in Pit., Contribution a l'étude de la flore du Maroc, p. 72. 1931. Holotype: Sur *Opuntia ficus-indica*, Tanger ad Aine, Dalia, Afrique, Septentionale [Morocco], 25. IV. 1913, Herb. C.J. Pitard No. 435 (PC!). =*Torula herbarum* (Pers.) Link:Fr.

490. ***T. tritici*** Corda, Icon. Fung. 1:8. 1837. ≡*Hormiscium tritici* (Corda) Bonord., Handb. Mykol., p. 33. 1851. Type: Not located. Not identifiable from the description and illustration.

491. ***T. tritici*** (Lib.) Corda, Icon. Fung. 5:51. 1842. Nom. illeg. Art. 53.1. ICBN. Non Corda 1837. ≡*Oidium tritici* Lib., Pl. Crypt., Arduenna Coll. Cent. 4, No. 385. Anno 1837. ≡*Oidium tritici* Sacc. & Voglino, Syll. Fung. 4:46. 1886. Nom. illeg. Art. 53.1. ICBN. [as (Corda) Sacc. & Voglino]. Holotype: Ad folia viva *Triticum repens* L. (BR!). Isotype:(W!). =*Acrosporium* anamorph of *Blumeria graminis* (DC.) Speer.

492. ***T. tuberculariae*** Nees, Nov. Acta Acad. Caes. Leop.-Carol. German. Nat. Cur. 9:247. 1818. Holotype: (B!). Not identifiable. ≡*Tetracolium tuberculariae* (Nees) Kunze in Link in Willd., Sp. Pl. IV, 6(Pt. 1):125. 1824. See Hughes, Canad. J. Bot. 36:834. 1958.

493. ***T. tuberculariaeformis*** C. Richon, Cat. Champ. Marne, p. 436. 1889. Type: Saint-Amand, [Belgium], Automne. Not located. Not identifiable from description.

494. ***T. tuberum*** Corda, Icon. Fung. 6:5. 1854. ≡*Oospora tuberum* (Corda) Sacc. & Voglino, Syll. Fung. 4:17. 1886. Holotype: Auf trockenen Stücken von *Tuber nigrum* Bull. (PR 155701!). Not identifiable; possibly a yeast, fide W. Gams, *Cephalosporium*-artige Schimmelpilze (Hyphomycetes), p. 216. 1971.

495. ***T. tumefaciens*** Vuill., Encycl. Mycol., Paris 2:113. 1931. Original strain found at Strasbourg, Leg. A. & R. Sartory & M. & J. Meyer. =Blastomycete

496. ***T. tumefaciens*** Coudert, Guide Pratique de Mycologie Médicale, Paris, p. 275. 1955. Nom. illeg. Art. 53.1. ICBN. Falsely attributed by Coudert to A. & R. Sartory and M. & J. Meyer, Compt. Rend. Acad. Sci., Paris 187:318-320. 1928. =*T. tumefaciens* Vuill.

497. ***T. tyrocola*** (Beyerinck) Heinze & Cohn, Z. Hyg. Infektionskrankh. 46:358. 1904. ≡*Saccharomyces tyrocola* Beyerinck, Centralbl. Bakteriol., 1 Abt., Originale 6:44. 1889. =Blastomycete.

498. ***T. ulmicola*** Rabenh., Deutschl. Krypt.-Fl. 1:35. 1844. Type: Not located. Excluded from *Torula* based on the description.

499. ***T. umbilicata*** Rivolta, Dei parassiti vegetali, p. 439. 1873. [as *alba* vel *umbilicata*]. ≡*Oospora umbilicata* (Rivolta) Sacc., Syll. Fung. 10:512. 1892. Type: Not preserved. Possibly a *Scopulariopsis* sp., fide W. Gams, *Cephalosporium*-artige Schimmelpilze (Hyphomycetes), p. 220. 1971.

500. ***T. uniformis*** Peck, Annual Rep. New York State Mus. 33:27. 1883. Holotype: On dead maple bark, [Village of] Quaker Street, [Schenectady County], New York, June, Leg. C.H. Peck (NYS!). ≡*Hormiscium uniforme* (Peck) Sacc., Syll. Fung. 4:263. 1886. =*Cryptocoryneum condensatum* (Wallr.) Mason & S. Hughes ex S. Hughes, Rimington, Nat. Hist. Scarborough Distr. 1:161. 1953; Canad. J. Bot. 36:758. 1958.

501. ***T. uredinis*** (Link) Fr.:Fr., Syst. Mycol. 3:503. 1832. ≡*Oidium uredinis* Link in Willd., Spec. Plant. 6(Pt. 1):123. 1824. ≡*Oospora uredinis* (Link) Wallr., Fl.

Crypt. Germ. 2:183. 1833. Type: Leg. Ehrenberg circa Berlinum. Not located. A fungus of uncertain position.

502. ***T. utilis*** Henneberg, Handbuch der Gärungsbakteriologie, Berlin, Zweite, Auflage. 1:405. 1926. Type Culture: CBS 621 ≡*Torulopsis utilis* (Henneberg) Lodder, Verh. Kon. Ned. Akad. Wetensch., Afd. Natuurk., Tweede Section 32:144. 1934. ≡*Cryptococcus utilis* (Henneberg) Anderson & Skinner, Mycologia 39:166. 1947. ≡*Candida utilis* (Henneberg) Lodder & Kreger, The Yeasts, a Taxonomic Study, ed. 1, p. 546. 1952. Teleomorph: *Pichia jadinii* (Sartory & R. Sartory, J. Weill & J. Mey.) Kurtzman fide Kurtzman in Kurtzman & Fell, The Yeasts, a Taxonomic Study, ed. 4, p. 314. 1998.

503. ***T. valdiviensis*** Sacc., Syll. Fung. 4:260. 1886. ≡*Torula lechleriana* Thüm. 1879, nec. P.A. Saccardo, 1878.

504. ***T. variabilis*** E. Pribram., Ergebn. Physiologie 24:95. 1925. Type: Not located. =*Phialophora jeanselmei* (Langeron) Emmons, fide L. Berger & Langeron, Ann. Parasitol. Humaine Comp. 24:588. 1949. [as *Torula bergeri* M. Langeron]. =*Exophiala jeanselmei* (Langer.) McGinnis & Padhye.

505. ***T. velutina*** Preuss, Linnaea 25:73. 1852. Type: Not located at B.

506. ***T. velutina*** Fuckel, Symb. Mycol., p. 348. 1870. Nom. illeg. Art. 53.1. ICBN. Non Preuss, 1852. **Lectotype designated herein**: Ad lignum *Salicinum* putridum, Münchau ca. Hattenheim [L. Fuckel]. Fungi Rhenani Exsic. No. 1907. (G!). Isolectotypes: (B!, FH!, K!, L!,). ≡*Torula fuckelii* Sacc., Syll. Fung. 4:250. 1886. ?=*Melanconium atrum* Link fide Hughes, Canad. J. Bot. 36:783. 1958. See the discussion of *Melanconium* Link by Sutton, Persoonia 3:193-198. 1964. *Trimmatostroma salicis* Corda also present in the type material.

507. ***T. vermicularis*** Corda, Icon. Fung. 1:8. 1837. Holotype: In ligno *Rosae caninae* prope Reichenberg. PR 155702!. ≡*Hormiscium vermiculare* (Corda) Sacc., Syll. Fung. 4:264. 1886. ≡*Taeniolella vermicularis* (Corda) S. Hughes, Canad. J. Bot. 36:818. 1958.

508. ***T. verrucosa*** Vouaux, in de Lesdain (1907) 1908, Bull. Soc. Bot. France 54:697. (1907) 1908. Holotype: France, Parc de Versailles, Trianon, in *Lecanora chlarotera* apothecia on *Juniperus*, 24 Oct. 1907. Leg. M. Bouly de Lesdain. (Herb. Vouaux). ≡*Sirothecium verrucosum* (Vouaux) Keissl, Oesterr. Bot. Z. 60:57. 1910. ≡*Vouauxiella verrucosa* (Vouaux) Petr. & Syd., Repert. Spec. Nov. Regni Veg. Beih. 42:483. 1927. See Hawskworth, Bull. Brit. Mus. Nat. Hist. Bot. 6:288. 1979.

509. ***T. verrucospora*** (P.N. Mathur & G.P. Singh) B. Sutton, Mycological Papers I.M.I. 167:67. 1993. ≡*Pseudotorula verrucospora* P.N. Mathur & G.P. Singh, Ind. Phytopath. 17:306. 1964. Holotype: On *Hibiscus abelmoschus*, India, Rajasthan, Budha Pushkar, Ajmer, Oct. 1961, Leg. G. Singh, (IMI 115055). Isotype: IARI. =*Torula herbarum* (Pers.) Link:Fr. forma *quaternella* Sacc.

510. ***T. verticillata*** Sacc., Bull. Soc. Roy. Bot. Belgique 35:131. 1896. Holotype: In foliis putrescentibus orchidearum epiphytarum in Brasilia. 1895. Leg. Binot. (PAD!). An actinomycete is present in the type material.

511. ***T. vinosella*** Sacc., Myco. Ven. Cent. 9, No. 1057. Anno 1877; Michelia 1:265. 1878. ≡*Oospora vinosella* (Sacc.) Sacc., Fungi Ital. Delin. Tab. 874. 1881. 4:20. 1886. **Lectotype designated herein**: Bosco Montetlo (Treviso), in Polyporo

See Errata

Pede Caprae udo, sociis *Penicillio*, *Cladosporio*, *Aspergillo*, Oct. 1876. (PAD!). Isolectotype: (FH!). Based on an Actinomycete.

512. ***T. virescens*** (Link) Sacc., Nuovo Giorn. Bot. Ital. 8:190. 1876. ≡*Oidium virescens* Link in Willd., Sp. Pl. IV, 6(1):124. 1824. ≡*Oospora virescens* (Link) Wallr., Fl. Crypt. Germ. 2:184. 1833. Type: Not seen. ≡*Gliomastix virescens* (Link) Dal Vesco & Peyronel, Allionia 14:36. 1968.
513. ***T. viridescens*** Bonord., Bot. Zeit. Berlin 19:195. 1861. ≡*Oospora viridescens* (Bonord.) Sacc. & Voglino in Sacc., Syll. Fung. 4:23. 1886. Type: Not located. Spores jointed, globose, slightly translucent.Not identifiable from the description.
514. ***T. vitellina*** Preuss, Linnaea 24:104. 1851. Holotype: An Holz von Fass, das mit Honig in Berühung war (B!). ≡*Oospsora vitellina* (Preuss) Saccardo & Voglino in Sacc., Syll. Fung. 4:21. 1886. An unclear mixture, possibly a yeast, fide W. Gams, *Cephalosporium*-artige Schimmelpilze (Hyphomycetes), p. 220. 1971.
515. ***T. viticola*** Allesch., Ber. Naturwiss. Vereins Landshut 12:106. 1892. Holo type: An faulenden Reben von *Vitis vinifera*, Um München: Isaranlagen beim Freibade, 26.1.84, Leg. A. Allescher. (M!). =*Torula herbarum* (Pers.) Link:Fr.
516. ***T. vulgaris*** É. Vidal, Compt. Rend. Sommaire Séances Mém. Soc. Biol. 31:3, 7. (1870). 1880; Ann. Dermatol. Syphiligr., Ser. 2, 3:23. 1882. Type: Not preserved. =Blastomycete, based on description. Mycelium absent and spores are ovoid 4.0-4.5 x 2.0-2.5 µm.
517. ***T. wehmeri*** Hanzawa & S. Takeda, Arch. Mikrobiol. 2:10-11. 1931. Type: Not preserved. This species was isolated from boned cod-fish. =Blastomycete.
518. ***T. welwitschiae*** Thüm., Inst. Revista Scien. Litt., Coimbra (Coimbra Univ. Ist. Coimbra) 27:8. 1879. Holotype: In foliis submarcidis *Welwitschiae mirabilis* Hook. fil. Coimbra in museo botanico. 1878. No. 77, Leg. A. Möller. (B!). Isotype: (K!). The specimens contain clumps and chains of oval, light brown cells. Ostiolate pycnidial structures are also present with 1-celled, hyaline conidia measuring 1.0 mm in diam.
519. ***T. (Cladosporium) werneckii*** (Horta) Coudert, Guide Pratique de Mycologie Médicale, pp. 274, 320. 1955. [as *wernecki]*. ≡*Cladosporium werneckii* Horta, Rev. Med. Cirwig. Brasil 29:274. 1921. [as *wernecki*]. ≡*Dermatium werneckii*(Horta) C.W. Dodge, Medical Mycology, p. 676. 1935. [as *wernecki*]. =*Aureobasidium mansonii* (Castagne) W.B. Cooke, Mycopathol. Mycol. App. 17:34. 1962.
520. ***T. wiesneri*** Zikes, Akad. Wiss. Wien. Sitzungsber. Math.-Natwiwiss. Kl. Abt. 1, 118:1127. 1909. ≡*Oospora wiesneri* (Zikes) Sacc. in Sacc. & Trotter, Syll. Fung. 22:1241. 1913. Type: Not preserved. Not identifiable, fide W. Gams, *Cephalosporium*-artige Schimmelpilze (Hyphomycetes), p. 220. 1971.

Acknowledgements

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A NEW GIANT XYLARIA FROM INDIA

Alaka Pande, Vimal Waingankar
Mycology & Plant Pathology Department, Agharkar Research Institute,
Pune 411 004, India
and
L. Prasad, Y. & J.G. Vaidya
Botany Department, University of Pune, Pune 411 007, India

Abstract: *Xylaria monstrosa* n. sp. is being described for a gigantic form of Xylaria from India.

Key words: new species, India, F. Xylariaceae

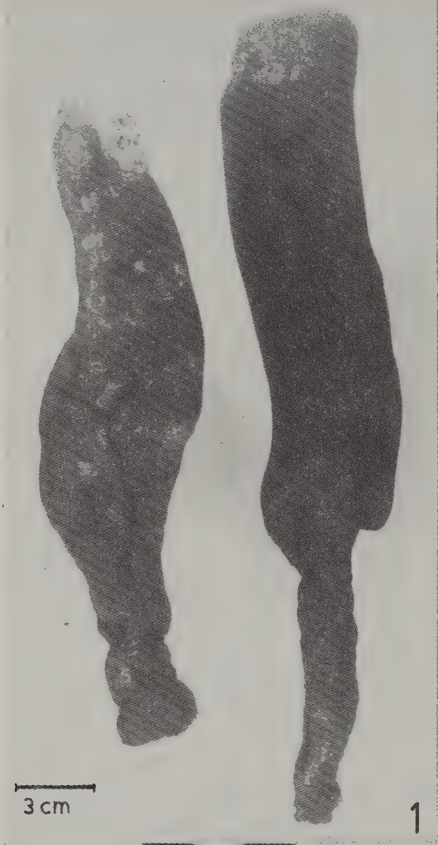
During routine mycological studies at A.R.I., Pune, we collected a massive Xylaria. The collection came from Coorg, Karnataka, where a patch of about 10 giant stromata was seen, standing erect amongst the litter in the moist evergreen forest. Interestingly the fruiting bodies were found inside a sacred grove, a patch of less disturbed evergreen forest, of about 25 ha of undulated land, surrounded by coffee plantations. (Sacred groves in Coorg are owned by the State Forest Department and are protected by the local people through community consensus). The litter quality: decomposing and single layered litter dark brown in colour, was composed of many layers of degraded leaves. The litter depth was approximately 5 cm. Nearby plant species were *Persea macrantha, Euonymus indicus, Macaranga* peltata (all with about < 10 cm DBH); undergrowth was of *Celtis philippinensis, Xanthophyllum flavescens, Gomphandra polymorpha, Myristica dactyloides, Goniothalamus cardiopetalus, Archidendron monadelphum, Dichapetalum geloiodes, Dimocarpus longan, Nothopegis beddomei, Knema attenuata, Beilschmiedia wightii, Strombosia ceylanica, Tabernaemontana heyneana, Psychotria spp., Glochidion spp.*

Xylaria monstrosa sp. nov. (Photo 1-4)

Stromata recta vel rara curvata, cylindrica, stipitata, laevia, extus viridi flava, nigrella ubi siccatus, intus alba, 30-35 cm alta, 4-6 cm diam., stipetes cylindrici, 6 - 8 cm longa et 2.5 - 3.5 cm diam.; stromata rotundata ad apicem; perithecia numerosa, innata immersa, ostiola punctata vel papillata; perithecia 0.7 - 1 x 0.6 - 0.8 mm; asci numerosi, cylindrici, stipitati, unitunicati, 55 - 95 x 7 - 12 µm; apparatus apicalis J+; ascosporae brunnolae vel brunneae, unicellulares, fusoideae, naviculares, 10 - 20 x 3.5 - 7 µm. rima germinstiva recta.

Ad Coorg (Karnataka, India), dt. 29.vii.1999; Leg. L. Prasad Y. Holotypus praditae. in AMH sub numero 8281

Stromata erect, mostly straight, rarely bent or curved, solitary, cylindrical, stalked, apex rounded, or rarely notched in the upper part, surface colour yellowish green, with black dots of ostioles spread over entire surface, interior white. Stalk concolorous,



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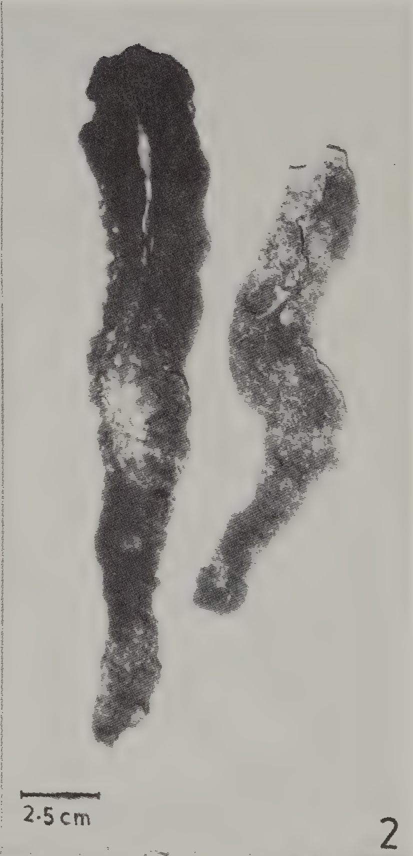

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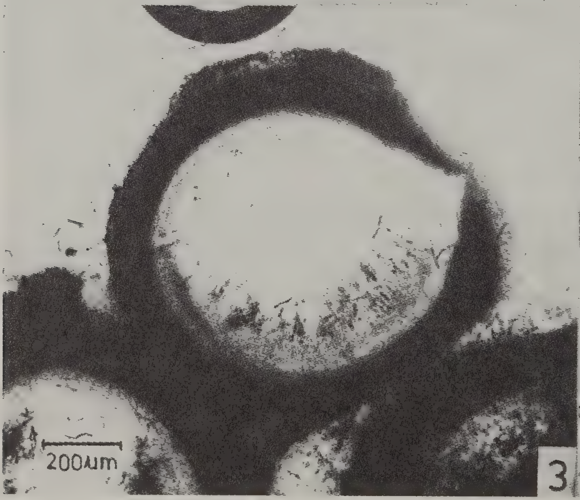

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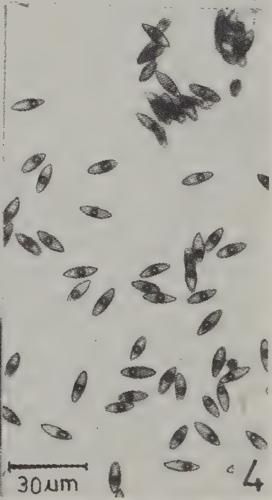

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slightly narrow, cylindrical, 6 - 8 cm long, 2.5-3.5 cm diameter; entire stroma 30 - 35 cm long, 4 -6 cm diameter. Surface becoming black and wrinkled on drying, stroma sometimes splitting vertically. Perithecia numerous, innate, in one layer below the surface of stroma, ostioles punctate or slightly papillate; perithecia 0.7 - 1 x 0.6 - 0.8 mm. Asci numerous, cylindrical, stipitate, octosporous, asci 55 - 95 x 7 - 12 µm, paraphysate, apical apparatus J+. Ascospores light brown to brown, one celled, navicular or fusoid, slightly pinched at both tips, 10 - 20 x 3.5 - 7 µm, with germ slit straight, running entire length.

Collected at Coorg (Karnataka, India) as growing in soil, in litter dt. 29th July 1999, Leg. L.Prasad Y. AMH 8281 (Holotype).

The impressive stature of the present collection led us to a literature survey (Dennis, 1956; Rogers, 1984, Saccardo, 1886, 1891, 1913; Subramoniam & Rao 1978) for similar gigantic forms of the genus. A comparison among the large sized stromatal species with the present collection is shown in Table I.

The present collection is described as a new species under *Xylaria monstrosa* sp. nov., the specific epithet indicating the giant size of the stromata.

Table 1: comparison of *Xylaria* species with large stromata

Species	Stromata	Stipe	Perithecia	Asci	Ascospores
X. herculea (Miq.)Cooke	10-25 cm	Short, Hollow	-	-	20-24 x 6-8 µm
X. macropoda Speg.	Upto 24 cm Cracked Surface	50-10 x 1-1.5cm well defined	0.8-1 mm diam.	6-75 x 6 µm	11.5-15 x 3.8 - 5-7 µm
X. borivliensis Subr. & V.G. Rao	10-12 cm smooth	solid , slender	250-850 x 176-375 µm	-	11.5-15 x 3.8 - 5.7 µm
X. mascarensis Cooke	17-4 cm	7 cm	-	-	-
X. poitei (Lev.)Fr.	15 x 2-3 cm	short or obsolete	0.7-1 mm	130 x 7-8 µm	14-18 x 5.5-7.5 µm
Xylaria Monstrosa sp.nov. (present collection)	30-35 x 4-6 cm, smooth, yellow-green when fresh	4-6 x 1.5-2.5 cm, solid, cylindrical	0.7-1 x 0.6-0.8 mm	55-95 x 7-12 µm	10-20 x 3.5-7 µm

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Xylaria monstrosa: 1. Fresh stromata 2. Dried stromata 3. Perithecium 4. Ascospores

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DALDINIA DECIPIENS SP. NOV AND NOTES ON SOME OTHER EUROPEAN DALDINIA SPP. INHABITING BETULACEAE

Marc Stadler, Manuela Baumgartner and Hartmund Wollweber
Naturwissenschaftl. Verein (Mycological Section)
and Bayer AG, PH-R LSC-NP
P.O. Box 10 17 09, D-42096 Wuppertal, Germany
phone +49-202-7160415; fax +49-202-364492
e-mail: marc.stadler@t-online.de;

Yu-Ming Ju
Institute of Botany
Academia Sinica
Taipei, Taiwan

Jack D. Rogers
Department of Plant Pathology
Washington State University
Pullman, Washington, USA

Daldinia decipiens sp. nov., associated with ***Betula***, and the known species ***D. lloydii*** were both collected and identified from several locations in Germany. The anamorph of ***D. loculata*** is also described. SEM studies of ascospores and further observations on ***Daldinia*** spp. associated with Betulaceae in Europe (***D. fissa, D. lloydii, D. loculata*** and ***D. petriniae***) are given.

Key words:systematics, Xylariaceae

Colour codes in descriptions follow Rayner (1970). JDR and Ww refer to the personal herbaria of J. D. Rogers and H. Wollweber, respectively. If not indicated otherwise, all specimens and cultures are deposited at the mycological herbarium of the Fuhlrott Museum (Wuppertal, Germany) and can be obtained from there. The methods for preparation and propagation of cultures, protocols for extraction of cultures and stromata, measurements of HPLC-based metabolite profiles, and generation of PCR data were described in detail by Stadler et al. (2001a, 2001b), where all previously examined materials of related species are also listed. The taxonomy of known ***Daldinia*** spp. species follows the monograph by Ju et al (1997), subsequent descriptions by Ju et al. (1999) and the key in Rogers et al., (1999), respectively. Recently, the current status of ***Daldinia*** in Europe was summarised in German (Wollweber and Stadler, 2001), including further records of **Daldinia** in Germany and Europe, which were also compared to the ones described in the present paper.

Daldinia decipiens Wollweber & M. Stadler, *sp. nov.*
Figs. 1, 2 and 4a.

(= "**Daldinia** sp. from Denmark")- Ju et al. Mycotaxon 71, p. 411 (1999).

ETYMOLOGY: deceiving; referring to the apparent correspondence of this species to several other members of the genus.

Stromata ad lignum *Betulae*, semiglobosa vel subsessilia, frequenter brevia stipitata, stipitibus 3-8 mm alta, solitaria vel aggregata, superficie confragosa vel tumulis peritheciorum conspicuis, 6-25 mm diam x 6-15 mm alta, externe rufobrunnea vel vestutate denigrata, sub superficie granulis sanguineis conspersa, granulis purpureis in KOH dissolutis; textura inter perithecia brunnea medullosa vel lignea; textura sub peritheciis zonis alternantibus composita, zonis fuscis medullosis vel ligneis, 0.1 - 0.6 mm crassis et zonis atrobrunneis vel nigrobrunneis medullosis vel ligneis, persistentibus, 0.1 - 0.5 mm crassis praedita.

Perithecia tubularia vel lanceolata, rara obovoidea, 0.2 - 0.4 mm diam x 0.4 -0.8 mm alta. Ostiola obsoleta. Asci 180-200 μm longitudine tota x 9 - 10 μm crassi, partibus sporiferis 90-110 μm longitudine, stipitibus 90 - 100 μm longitudine, annulo apicali 4.5 - 5 μm crasso x 0.5 - 0.8 μm alto, in liquore iodato Melzeri cyanescente.

Ascosporae brunneolae, unicellulares, ellipsoideo-inequilaterales vel ellipsoideae, apicibus attenuatis, (13-)14 - 18(-20) x 6.5 - 10(-11) μm, rima germinativa recta, in latere convexo praeditae; perisporium in KOH dehiscens, leve; episporium leve.

Stromata on wood of **Betula**, semiglobose or subsessile, frequently with a short stipe of 3-8 mm height, solitary to aggregated, confragose or with conspicuous perithecial mounds, 6-25 mm diam x 6-15 mm high; surface of young stromata reddish brown, blackened and dull in age; purple granules immediately beneath surface, with KOH-extractable pigments purple (100), dark livid (80) or vinaceous purple (101); the tissue between perithecia brown, pithy to woody; the tissue below the perithecial layer composed of alternating zones, the darker zones dark brown or blackish brown, pithy to woody, 0.1 - 0.5 mm thick, the lighter zones fuscous, pithy to woody, persistent, 0.1 - 0.6 mm thick, the lighter zones 0.75 – 2 times thicker than the darker ones, zonation extending into the stipe.

Perithecia tubular or lanceolate, rarely obovoid, 0.2 - 0.4 mm diam x 0.4 - 0.8 mm high. Ostioles obsolete. Asci 180-200 μm total length x 9-10 μm broad, the spore-bearing part 90-110 μm long, the stipe 90-100 μm long, apical ring 4.5 - 5 μm diam x 0.5 - 0.8 μm high, amyloid.

Ascospores light brown, unicellular, ellipsoid-inequilateral to ellipsoid, with narrowly rounded ends, (13-)14 - 18(-20) x 6.5 - 10(-11) μm, with straight germ slit over the entire spore-length on the more convex side; perispore

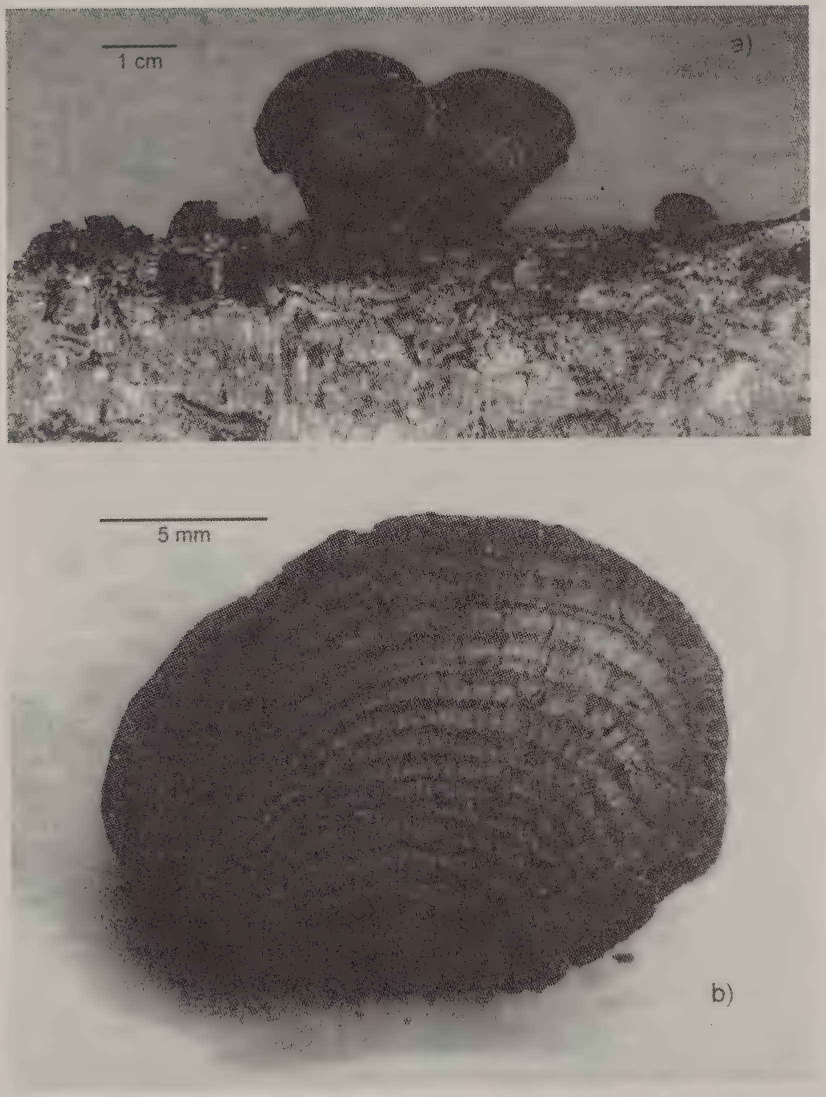

Fig. 1. Stromatal habitus of ***D. decipiens*** a) Stromata on substrate, b) characteristic internal zonation. Scale is indicated by bars.

dehiscent in 10% KOH, smooth; epispore appearing smooth under the light microscope, but showing fine transversal striations under the SEM.

CULTURES AND ANAMORPH: Colonies on 2% Difco Oatmeal Agar at ca. 23°C and under 12 h fluorescent light reaching the edge of 9 cm Petri dish in 1-1.5 wk, whitish, felty, azonate, with diffuse margins, becoming buff (45) to honey (64) with sporulation; reverse citrine (13), ultimately becoming blackish with age. Sporulating regions scattered over entire surface of colony. Conidiogenous structure with ***Nodulisporium***-like or a ***Sporothrix***-like branching pattern as defined in Ju and Rogers (1996). Conidiophores frequently arising from characteristic inflated hyphae, mononematous, unbranched or dichotomously branched, hyaline, coarsely roughened, 50 x 100 µm long x 2.5 x 3.5 µm diam, with 1-2 conidiogenous cells arising from each terminus. Conidiogenous cells terminal or intercalary, cylindrical, slightly swollen at top, hyaline, roughened, 13-22 x 2.5 - 4 µm. Conidia produced from percurrently proliferating conidiogenous cells or, infrequently, from sympodially proliferating conidiogenous cells. Conidia hyaline, smooth, subglobose to obovoid, frequently with an attenuated base, 7-8 x 4.5-5.5 µm.

SPECIMENS EXAMINED: GERMANY: North Rhine Westphalia Province, Warstein, Hamorsbruch, 05.X.2000, on trunk of ***Betula carpatica***, Wollweber, H. (CULTURED), Ww 3811, HOLOTYPE (M); North Rhine Westphalia Province, Wuppertal-Dornap, 24.I.1999, aged specimens on twigs of ***Betula pendula***, Stadler, M. (CULTURED), Ww 3542; Lower Saxony Province, Estetal, 7.III.1998, ***Betula***, Albers, J. and Grauwinkel, B. (CULTURED), Ww 3864; Lower Saxony Province, Minsener Oog, near Wangerooge Island, 30.IX.1981, ***Betula***, Grauwinkel, B. (CULTURED), Ww 3863;. Hamburg, Fischbeckerheide 21.III.1998, ***Betula***, Kriese, S., Albers, J. and Grauwinkel, B., Ww 3865 - Brandenburg Province, Krausnick, 16.IX.1995, ***Betula*** sp., Kummer, V. Potsdam, Germany, Ww 3896.

SWEDEN: Scania Province, Kropp (near Helsingborg), 31.XII.1994, Hanson, S.-Å., (CULTURED), pile of ***Betula pendula*** (JDR), (Ju et al., 1999), Ww 3699.

NOTES: Together with another yet undescribed species ("***Daldinia*** sp. from Russian Far East"), the above listed collection of "***Daldinia*** sp. from Denmark" was reported by Ju et al. (1999). The material was collected near Helsingborg in the southernmost province of Sweden and sent to JDR. As already mentioned in Ju et al. (1999) the fungus now named ***D. decipiens*** (as well as the morphologically similar ***Daldinia*** sp. from Russian Far East) bear some resemblance with ***D. cudonia.*** We found that the species from Sweden and "Russian Far East" differed from one another in their secondary metabolite profiles of submerged cultures, as well as in their PCR-based genetic fingerprints (Stadler et al., 2001a, 2001b).

Actually, the stromatal morphology in ***D. decipiens*** may be quite variable. The stromata from Sweden and the ones from Germany herein referred to as Ww 3542 only had a small stout stipe (which was lacking in some specimens), while all other collections contained fruitbodies with a rather prominent stipe.

The stromata of the ***Daldinia*** sp. from ***Carpinus*** ("Russian Far East") are stipitate as well but differ from those of ***D. decipiens*** in having smaller ascospores and slightly smaller conidia, which are mostly not attenuated (Ju et al., 1999). Based on the examination of several specimens from Northern Germany, we conclude that ***D. decipiens*** is not conspecific with the tropical American species, ***D. cudonia***. The systematic position of the species from "Russian Far East" remains to be clarified.

From the similar anamorphic morphology and Minisatellite PCR data (Stadler et al., 2001b), a close relationship between ***D. decipiens*** and ***D. petriniae*** can be deduced. These species, however, differ in stromatal morphology and ascospore size, and they also contain different stromatal metabolites. While stromata of the newly described species mainly contains the binaphthalene derivative, BNT, those of ***D. petriniae*** yield additional, yet unknown compounds (Stadler et al., 2001a). Furthermore, the newly described species was found to be consistently associated with ***Betula*** spp. while ***D. petriniae*** was most frequently reported from ***Alnus*** spp. Interestingly, the ***Daldinia*** sp. from Russian Far East is associated with another Betulaceae genus (***Carpinus***). These data point toward an adaptive radiation during the coevolution of ***Daldinia*** and Betulaceae (see further below).

The anamorph of ***Daldinia loculata*** (Fig. 3)

The revision by Ju et al. (1997) did not include the anamorph **of *D. loculata*** for lack of culturable material, and the data in literature for the anamorph of this species were somewhat ambiguous. The following description is based on cultures which were previously characterised by PCR and DNA sequencing studies (Johannesson et al., 2000; Stadler et al., 2001a). We also included the culture of a ***D. loculata*** specimen collected from burnt ***Alnus*** in Germany, which we recently obtained.

SPECIMENS EXAMINED: GERMANY: Lower Saxony Province, Elsfloth, Strohauser Plate, burnt ***Alnus glutinosa***, 15.VIII.1998, Albers, J. & Grauwinkel, B., Ww 3891 (CULTURED); GREAT BRITAIN: England, Surrey, Pirbright, burnt ***Betula pendula***, XI. 1991, Butterfill, G., K(M) 18694 (CULTURED), culture deposited at K. (KC1522), Ww 3691; England, Esher West End Common, ***Fagus***, X. 1993, P.M. Kirk, K(M) 24541 (CULTURED), culture deposited as KC1525, Ww 3696.

ADDITIONAL MATERIALS: CULTURE of TL 4630, ***Betula,*** Far Eastern Russia, see Johannesson et al. (2000); CULTURE of HJ 105, ***Betula,*** Sweden, Uppland, see Johannesson et al. (2000).

Colonies on 2% Difco Oatmeal Agar at ca. 23°C and under 12 h fluorescent light reaching the edge of 9 cm Petri dish in 1.5 wk, whitish, felty, azonate, with diffuse margins, becoming grayish with sporulation after 3-4 wk. Reverse at first white, after 1-2 weeks, turning greenish, blackening with age. Sporulating regions sparsely scattered over entire surface of colony. Conidiogenous structure with ***Nodulisporium***-like branching pattern as defined in Ju and Rogers (1996). Conidiophores mononematous, mostly dichotomously branched, hyaline, coarsely roughened, up to 100 µm long x

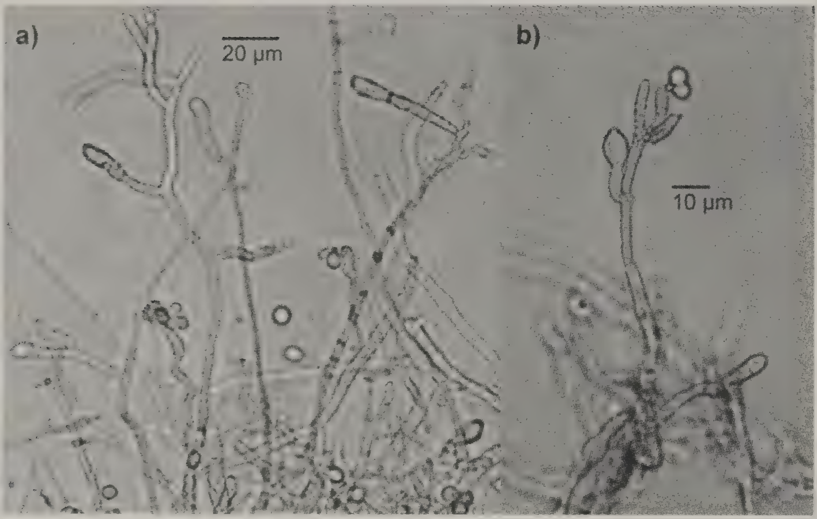

Fig. 2. Microphotographs of ***D. decipiens***.(phase contrast, 400x, from culture): **a)** ***Sporothrix***-like conidiophores; **b)** ***Nodulisporium***-like conidiophore. Scale is indicated by bars.

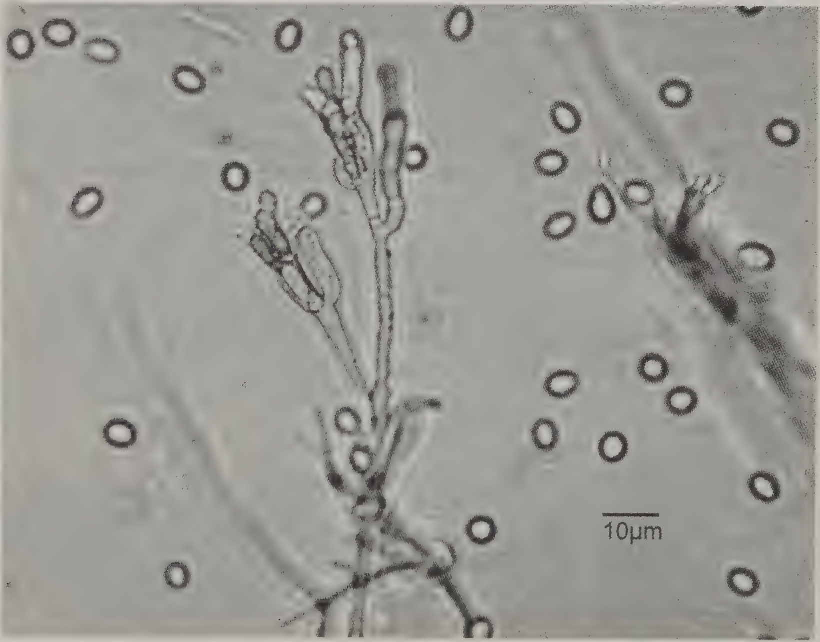

Fig. 3. Microphotograph of ***D. loculata*** (from culture): ***Nodulisporium***-like conidiophores and conidia (phase contrast 1000x); Scale is indicated by bar.

3.5-4.5 µm diam, with 1-2 conidiogenous cells arising from each terminus. Conidiogenous cells terminal or intercalary, cylindrical, hyaline, with apical scars, 11-17 x 3.5-4 µm. Conidia produced from sympodially proliferating conidiogenous cells, hyaline, smooth, subglobose to globose, 6-7.5 x 4.5-5 µm.

Jong (1970), reported a similar branching pattern but larger conidia and conidiophores for his ***Daldinia spp.*** collected in USA from ***Alnus*** and ***Betula***, respectively. Martin (1969), on the other hand, reported an entirely different anamorph for ***D. loculata***. As we found similar anamorphic structures and genetic fingerprints in all our cultures made from ***D. loculata*** specimens, we think that the aforementioned authors had actually studied different species.

First report of *D. lloydii* from Germany

SPECIMENS EXAMINED: GERMANY: Brandenburg Province, Neuendorf am See, 09.VII. 1995, ***Betula***, immature stromata bearing conidiogenous structures, Kummer, V., Ww 3893; Mecklenburg-Vorpommern Province, Anklam near Pinnow, 30.VIII.1974, ***Betula***, Kreisel, H., Ww 3827; Mecklenburg-Vorpommern Province, Stralsund, 6. VIII.1962, ***Betula***, immature specimens, Scheidemann, L., Herbar Kreisel, H., Ww 3829, Saxony Province, Wellaune near Leipzig, 5. VIII. 1965, ***Betula***, Kreisel, H. Ww 3830. Further investigated materials from other locations see Stadler et al. (2001a)

D. lloydii is another ***Daldinia*** sp. associated with Birch. It was first described in Lloyd (1919) as ***Hypoxylon fissum*** p.p. and later incorporated into ***Daldinia*** by Ju et al. (1997). In a previous report (Stadler et al., 2001a), we gave first evidence on the occurrence of this species in Europe (Austria, Romania, Slovakia). Based on investigation of materials from the personal herbaria of H. Kreisel and V. Kummer, we were able to confirm the occurrence of this species in Germany as well. These findings confirmed that ***D. lloydii*** is closely associated with ***Betula*** spp.

SEM studies and further notes on *Daldinia* spp. inhabiting Betulaceae in Europe (Fig. 4, Tab. 1))

It seems quite probable that previous records of ***Daldinia*** spp. from ***Betula*** in Europe correspond with ***D. decipiens***. However, several species are present on this substrate. In agreement with Johannesson et al. (2000) we found that the most frequent taxon associated with burnt ***Betula*** is ***D. loculata***, which differs from ***D. decipiens*** by having smaller, broadly ellipsoid ascospores and in other characters. However, for instance the records from ***Betula*** previously reported as "***D. concentrica***" by Whalley and Watling (1980) with rather large ascospores should be reassessed.

In terms of ascospore size and shape, ***D. decipiens*** may also be confused with ***D. grandis***, a species erected by Child (1932) and later reported from other locations in America and New Zealand (Ju et al., 1997). Actually, ***D. grandis*** is characterised by, e.g., producing large, sessile stromata (of up to 8 cm size!), ascospores of up to 25 µm length, and an anamorph showing a

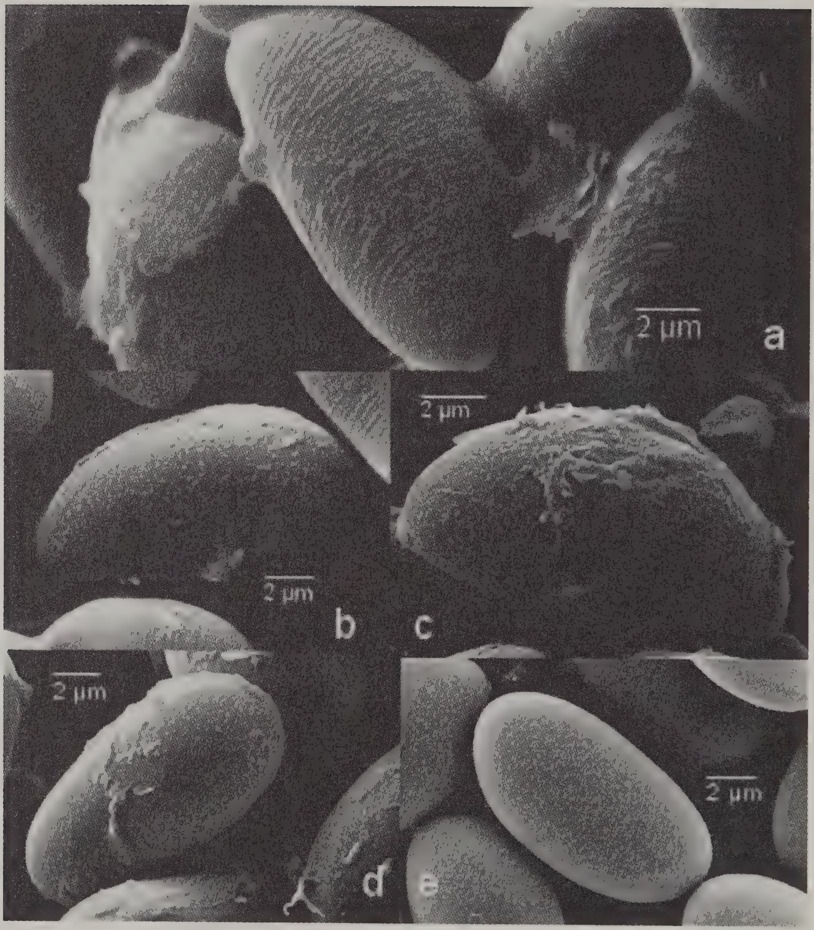

Fig. 4. SEM microphotographs of ascospores (magnification: 5.000x) of ***Daldinia*** spp. inhabiting Betulacae in Europe: **a)** ***D. decipiens***, Holotype **b)** ***D. petriniae***, Ww 3298 **c)** ***D. lloydii***, Ww 3829 **d)** ***D. loculata***, Ww 2885; **e)** ***D. fissa*** Ww 2889. Scale is indicated by bars. For origin of materials depicted in **b), d)** and **e)** see Stadler et al. (2001a).

Tab. 1: ***Daldinia** spp.* on Betulaceae in Europe and Far Eastern Russia: Comparison of characteristic features, including results previously reported by Ju et al. (1997), Ju et al. (1999), and Stadler et al. (2001a)

	D. loculata	***D. fissa***	***D. petriniae***	***D. lloydii***	***D. decipiens***	***Daldinia* sp. "Russ. Far East"**
Distribution/ preferred substrates	circumpolar, mainly on ***Betula***, pyrophilic	circumpolar on various hosts including ***Betula***, pyrophilic	circumpolar, preferably on ***Alnus***	circumpolar, only known from ***Betula***	Europe, only known from ***Betula***	Asia, only known from ***Carpinus***
Ratio of concentric zones (light:dark)	1.5-3:1	5-8:1	2-3:1	2-4:1	0.75-2:1	1:1
Ascospore size	10-14 x 5-7 µm	11-15 x 6-8 µm	12-16 x 6-7.5(-8) µm	11-16(-18) x 6-9 µm	(13-)14-18(-20) x 6.5-10 (11) µm	13-15 x 6.5–7 µm
Ascospore ornamentation (SEM)/ Ascospore shape	smooth/ broadly ellipsoid	smooth/ broadly ellipsoid	striated/ narrowly rounded ends	striated/ narrowly rounded ends	striated/ narrowly rounded ends	unknown/ narrowly rounded ends
KOH-extractable stromatal pigments	purple (strong)*	purple (very strong)*	olivaceous or purple**	olivaceous, greenish**	purple	purple
Anamorph (Ju and Rogers 1996)	***Nodulisporium***	***Nodulisporium*, *Periconiella*** or ***Sporothrix***	***Nodulisporium*** or ***Sporothrix***	unknown	***Nodulisporium*** or ***Sporothrix***	***Nodulisporium*** or ***Sporothrix***
Conidiogenesis	holoblastic	holoblastic	mainly enteroblastic	unknown	mainly enteroblastic	mainly enteroblastic

* owing to the presence of large amounts of BNT; **owing to the presence of specific, yet unknown metabolites

Virgariella-like branching pattern (Ju et al., 1997). We did so far not find any indication that this species is present in Europe. A collection from ***Ulmus*** sent to us by A.J.S. Whalley (AJSW 1000, see Rogers et al., 1999) was re-examined and cultured. It corresponded with ***D. concentrica*** with regard to morphological characters, PCR data and secondary metabolite profiles.

In Fig. 4 the ascospores of five ***Daldinia*** spp. from Betulaceae are depicted for comparison. Interestingly, the spores of ***D. fissa*** and ***D. loculata*** are broadly ellipsoid and appear smooth under the SEM, while those of ***D. decipiens***, ***D. lloydii*** and ***D. petriniae*** have narrowly rounded ends and bear transverse striations as previously reported by Van der Gucht (1994) for three ***Daldinia*** spp. from Papua New Guinea. ***Daldinia fissa*** and ***D. loculata***, on the other hand, are pyrophilic (Ju et al., 1997, Johannesson et al., 2000, and references therein), and were found to contain extraordinarily large amounts of the binaphthalene, BNT, in their stromata (Stadler et al., 2001a). In the latter study, similar metabolite profiles in stromata of ***D. lloydii*** and ***D. petriniae*** (and in cultures of ***D. petriniae*** and ***D. decipiens***, respectively), had been noted. The anamorphs of the two latter species also produce conidia from percurrently proliferating conidiogenous cells. Some significant morphological and chemical features, which we find useful to separate these species are provided in Table 1.

Despite the fact that some questions remain to be solved (e.g. the anamorph of ***D. lloydii*** remains to be described and several specific metabolites of ***D. lloydii*** *and* ***D. petriniae*** are yet to be identified), these results point toward the existence of two different lineages of co-evolution between ***Daldinia*** and Betulaceae – a pyrophilic and a non-pyrophilic one.

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THREE NEW DALDINIA SPECIES WITH YELLOWISH STROMATAL PIGMENTS

Marc Stadler and Manuela Baumgartner
Bayer AG, Pharma Research, LSC-Natural Products
P.O. Box 10 17 09, D-42096 Wuppertal, Germany
phone +49-202-364637; fax +49-202-364492
e-mail: marc.stadler@t-online.de;

Hartmund Wollweber
Naturwissenschaftlicher Verein (Mycological Section)
D-42113 Wuppertal, In den Birken 73

Daldinia albofibrosa, Daldinia pyrenaica, and ***Daldinia steglichii***, three species with yellowish KOH extractable stromatal pigments, are newly described, based on previously undescribed combinations of teleomorphic and anamorphic characters. Their status as separate species is confirmed by HPLC-based secondary metabolite profiles, ultrastructural examination of ascospores by SEM, and genetic fingerprints.

Key words: systematics, Xylariaceae, chemotaxonomy

Pyrenomycetes of the genus ***Daldinia*** (Xylariaceae) are characterised by the presence of alternating light and dark-coloured ring zones in their entostroma. Their current classification is based on a revision by Ju et al. (1997), followed by a re-interpretation of the type species, ***D. concentrica*** (Bolt.:Fr.) Ces. & De Not. by Rogers et al. (1999). In the current generic concept, the importance of KOH-extractable stromatal pigments for intrageneric discrimination of ***Daldinia*** spp. is emphasised. The stromatal pigments of most ***Daldinia*** spp. are purplish, while those of at least three known species (***D. bakeri*** Lloyd, ***D. mexicana*** Y.-M. Ju, J.D. Rogers & F. San Martín, and ***D. childiae*** J.D. Rogers & Y.-M. Ju) yield a yellowish colouring matter. Few species of ***Daldinia*** possess different stromatal pigments, and on occasion, no apparent pigments were observed (Ju et al., 1997). Actually, these differences in pigmentation are due to the presence of specific stromatal colouring matters, which belong to different types of secondary metabolites (Stadler et al., 2001a). The chemical structures of some taxonomically important pigments were elucidated, which allowed for comparative studies on their occurrence in ***Daldinia*** by HPLC profiling. Concurrently, the genetic fingerprints of several ***Daldinia*** spp. as revealed from ARDRA and Minisatellite PCR were compared. Strong correlations between morphological, chemotaxonomical and molecular characters in many previously described species were noted (Stadler et al., 2001b). In some cases, the data obtained by this "molecular chemotaxonomy approach" were inconsistent, pointing towards the existence of further, previously undescribed ("cryptic") species.

The present paper deals with the results of an intensified evaluation of some records of ***Daldinia*** spp. yielding yellowish KOH-extractable stromatal pigments, whose morphology was not in accordance with ***D. childiae***. Due to these studies, further evidence is provided as to the identity of materials previously described in accuracy from France (Petrini and Müller, 1986) and Papua New Guinea (Van der Gucht, 1994), respectively.

Color codes in descriptions follow Rayner (1970). Ww refers to the personal herbaria of H. Wollweber, or respective notebook entries on specimens, which were obtained on loan (e.g. from the personal herbarium of H. Kreisel and the herbaria of G, K, L, M, WSP and ZT). If not indicated otherwise, all specimens are deposited in the mycological herbarium of the Fuhlrott-Museum (Wuppertal, Germany) and can be obtained from there.

SEM was carried out by means of a Philips XL 30 scanning electron microscope. Ascospores were prepared under a dissecting microscope from freeze-dried fragments of the perithecial layers of the ectostroma. Spores were not treated with Melzer´s reagent prior to SEM to remove the perispore. Characteristic motifs were selected for microphotography, and resulting images were processed using Analysis Pro 3.0 software (Soft Imaging Systems, Münster, Germany). Phase contrast microphotography and measurements of anamorphic structures were accomplished in water by means of a Leica light microscope, equipped with a photo tubus, at magnifications of 400x or 1000x, respectively. Ascospore measurements were carried out in Melzer´s iodine reagent. The methods for preparation and propagation of cultures, protocols for extraction of cultures and stromata, measurements of HPLC-based metabolite profiles and generation of PCR data were described in detail by Stadler et al. (2001a, 2001b). The taxonomy of previously described species follows the monograph by Ju et al. (1997), and the new key given in Rogers et al. (1999), respectively.

These previous publications also contain information on the origins of most materials belonging to the species ***D. childiae*** J.D. Rogers & Y.-M. Ju, ***D. clavata*** Henn., and ***D. grandis*** Child, which were studied for comparison.

Additional specimens of ***D. clavata*** from the Caribbean from the herbarium of H. Kreisel (Potthagen, Germany) also showed the typical characteristics reported by Ju et al. (1997) [CUBA: Nicaro, 3.III.1970, wood, Kreisel, H., No. 1839, Ww 3855; Calabazar, 9.II.1970, wood, Kreisel, H. No. 1637, Ww 3856; Calabazar, III.1971, wood, Kreisel, H. No. 3856, Ww 3857].

Daldinia pyrenaica M. Stadler & Wollweber, *sp. nov.*

Figs.1 - 4, 8 - 10, 15

[= ***Daldinia*** cf. ***loculata*** (Lév.)Sacc. ss. Petrini, L. & Müller, E. (1986): Mycologia Helv. 1: 501-627 and Fig. 42].

ETHYMOLOGY: Refers to the occurrence of this species in the montaneous French and Spanish Pyrenean region.

Stromata clavata, turbinata vel subglobosa, subsessilia vel brevia stipitata, solitaria vel aggregata. Stromata solitaria 10 - 25 mm diam x 15 - 25 mm alta. Stromata aggregata 60 mm longitudine x 40 mm alta x 25 mm crassa, externe rufobrunnea vel brunnea-vinacea, demum denigrata, tumulis perithecorium conspicuissimis, sub superficie granulis rufo-brunneis conspersa, granulis rufobrunneis, fulvis, isabellinis, vel melleis in KOH dissolutis; textura inter perithecia brunnea medullosa vel lignea, textura sub peritheciis zonis alternantibus composita, zonis griseobrunneis medullosis vel ligneis, 0.2 – 0.5 mm crassis et zonis fuscis medullosis vel ligneis, persistentibus, 0.2 – 0.7 mm crassis praedita. Perithecia lanceolata, 0.5 – 1.5 mm alta x 0.2 – 0.5 mm diam. Ostiola umbillicata.

Asci 220 - 285 µm longitudine tota, 10 - 15 µm crassi; partibus sporiferis 90 - 95 µm longitudine, stipitibus 130 - 195 µm longitudine. Annulo apicali discoideo, 4 µm alto x 1.5 µm crasso, in liquore iodato Melzeri cyanescente. Ascosporae brunneolae, unicellulares, ellipsoideo-inequateriales, apicibus angustatis, 13 - 17(-20) x 6.5 - 8(-9) µm, rima germinativa recta, longa in latere convexo praeditae, perisporium in KOH dehiscens, leve, episporium leve.

Stromata clavate, turbinate to subglobose, subsessile or with short stipe, solitary to aggregated, with very conspicuous perithecial mounds, solitary stromata 10 - 25 mm diam x 15 - 25 mm high, aggregated stromata 60 mm long x 40 mm high x 25 mm broad, surface reddish brown to vinaceous brown (84), blackening with age, with KOH extractable pigments reddish-brown, fulvous (43), apricot (42), isabelline (65), or honey (64), the tissue between perithecia pithy to woody, the tissue between the perithecial layers composed of alternating concentric zones, zonation extending into the stipe, the darker zones dark brown, pithy to woody, 0.2 - 0.5 mm thick, the lighter zones fuscous, pithy to woody, persistent, 0.2 - 0.7 mm thick, 1-2 times thicker than the darker ones. Perithecia lanceolate (0.5-1.5 mm high x 0.2-0.5 mm diam) to obovoid, 0.4 –1.2 mm diam, Ostioles umbillicate.

Asci 200 - 285 µm total length, 10 - 15 µm broad, the spore-bearing part 90 - 95 µm long, the stipe 130 - 195 µm long, with apical ring 4 µm high x 1,5 µm broad, bluing in Melzer´s iodine reagent. Ascospores brown, unicellular, ellipsoid-inequatorial, with narrowly rounded ends, 13 - 17(-20) x 6.5 – 8(-9) µm, germ slit straight, on the more convex side of the ascospore, perispore dehiscent with 10% KOH, smooth, epispore smooth under the light microscope. Upon SEM, faint transversal striations become visible.

CULTURES AND ANAMORPH Colonies on 2% Difco Oatmeal agar at ca. 20 °C and under 12h of fluorescent light reaching the edge of a 9 cm petri dish in 5-6 days, at first whitish, felty, zonate, with diffuse margins, becoming greenish brown when sporulating, reverse yellow-greenish, blackening with age, releasing brownish exudates into the agar, developing a characteristic sweet odour. Sporulating regions scattered over entire surface of colony. Conidiophores reaching a maximum height of 200 µm, mononematous, dichotomously or (sometimes) trichotomously branched, septate, hyaline, smooth or finely roughened, 2-2.5 µm diam, with one conidiogenous cell arising from each terminus, showing a ***Nodulisporium***-like or, less frequently, a ***Sporothrix***-like branching pattern as defined in Ju and Rogers (1996). Conidiogenous cells terminal or intercalary, cylindrical, hyaline, smooth, 10 - 25 x 2.5 - 3 µm. Conidia produced holoblastically from sympodially proliferating conidiogenous cells, hyaline, ovoid to dacryoid, smooth or finely roughened, 6.5 - 7(-8) x 4 – 5 µm. Anamorph on stromata similar, but conidia measuring 5.5 - 7(-8) x 4 – 5 µm.

SPECIMENS EXAMINED: SPAIN: Navarra Province, Señorio de Bertiz, 29. VI. 1999, Stadler, B. & M., Ww 3585 (conidiogenous stromata, CULTURED) and Ww 3586 (ascigenous stromata, CULTURED), on *Quercus petraea* (HOLOTYPE, M.); FRANCE, Pyrenees Atlantiques, Nay, Saligues-les-Bourdettes, 12.X.1981, wood, Petrini. L. & Candoussau, F. (Petrini and Müller, 1986, as ***D.*** cf. ***loculata***), ZT, Ww 3290; Pyrenees Atlantiques, Oloron, Foret de Bugangues, wood, X. 1981, Petrini, L. & Candoussau, F. (Petrini and Müller, 1986, as ***D.*** cf. ***loculata***), ZT, Ww 3291.

[ADDITIONAL MATERIAL: Specimens from ZT both included dried agar cultures, whose morphology corresponded with the ex-type cultures]

NOTES: ***D. childiae*** (as ***D. cf. eschscholzii***) and ***D. pyrenaica*** (as ***D. cf. loculata***) had already been recognised to be different taxa by Petrini and Müller (1986). Both species are similar regarding the following characters: yellowish stromatal pigments (reddish-brown in freshly collected conidiogenous specimens, due to high concentrations of secondary metabolites), presence of daldinin C and daldinals A and B as revealed from HPLC-based secondary metabolite profiles, similar ARDRA fingerprints, an anamorph with holoblastic conidiogenesis, and transversally striated ascospores as observed under the SEM (compare Figs. 15 and 16).

D. pyrenaica differs from ***D. childiae*** in having larger and broader ascospores and very prominent perithecial mounds, by the presence of conidiophores with a ***Sporothrix***-like branching pattern as defined in Ju and Rogers (1996) besides the common ***Nodulisporium***-like branching pattern, and by generally forming smaller conidia in culture (compare Figs 8-11). All collections of ***D. pyrenaica*** were made in the same geographic region where the holotype material of ***D. childiae*** had been found. Its identity with a variety of ***D. childiae*** therefore remained to be excluded. This was accomplished by a comparison of their Minisatellite PCR fingerprints (reported in Stadler et al., 2001b), and the comparison of size ranges of ascospores and conidia: The differences between both species became evident by the fact that materials of ***D. childiae*** from Austria, France, Japan, Switzerland, and USA all showed consistent morphology and PCR data, while differing in all before mentioned characters from ***D. pyrenaica*** (Stadler et al., 2001b).

Ascigenous stromata of a ***Daldinia*** sp. were encountered among the specimens deposited at M. (AUSTRIA, Rekawinkel, Wienerwald, near Vienna, V.1940, from ***Carpinus betulus***, Petrak, F. No. 2416, Ww 3602). This collection consisted of one fragment of a clavate stipitate fruitbody, 1.8 cm diam x 3 cm overall height, including a stipe of 1.5 cm, with very prominent perithecial mounds. The darker concentric zones were brown, 0.2-0.4 mm thick, while the lighter ones were honey (64), persistent, measuring 0.6 – 1 mm (2.5-3.5 times thicker than the darker ones); Perithecia were 1 mm high x 0.5 mm diam; ascospores brown, ellipsoid-inequaterial, with narrowly rounded ends, (15-)16-18 x 8-9(-10) µm, and the stromata contained prominent perithecial mounds. Weak isabelline (65) to weakly greyish KOH extractable stromatal pigments were observed. In methanolic stromatal extracts, azaphilones and benzophenones were detected by HPLC analyses in rather low yields (possibly due to their decay in the aged specimen). Because of the observed differences in KOH extractable pigments, the very prominent stipes and the lack of culturable material, the correspondence of this material remained unclear, even though it resembled ***D. pyrenaica***.

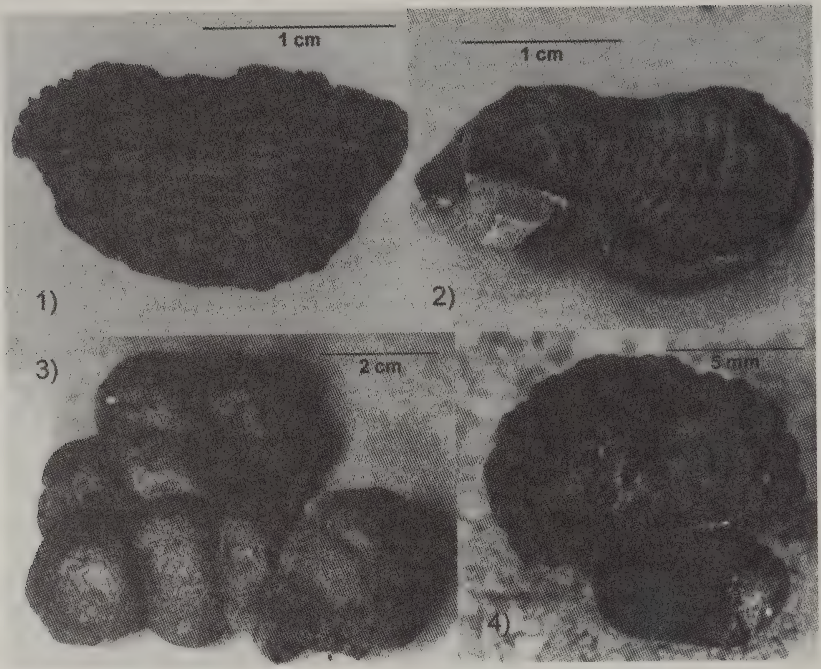
Daldinia steglichii M. Stadler, M. Baumgartner & Wollweber, *sp. nov.*
Figs. 5, 12, 19
[= "***Daldinia cf. grande***"; Van der Gucht, K., 1994. PH D Dissertation Univ. Gent, pp. 124-126 and plates No. 27-29; Van der Gucht, K., 1995. Bull. Jard. Bot. Nat. Belg. 64: 219–403, p. 265-266, Figs. 10 e-f and 11 g-h].

ETHYMOLOGY: Named in honour of Prof. Wolfgang Steglich (Munich, Germany), in recognition of his outstanding work on the identification of fungal secondary metabolites.

Stromata subsessilia vel brevia stipitata, 10-25 mm alta x 10-25 mm crassa, externe rufo-brunnea, denum denigrata, tumulis perithecorium inconspicuis, sub superficie granulis rufis, granulis isabellinis vel fuscis in KOH dissolutis; textura inter perthecia brunnea medullosa vel lignea, textura sub peritheciis zonis alternantibus composita, zonis atrobrunneis medullosis vel ligneis, persistentibus, 0.1 - 0.3 mm crassis et zonis griseobrunneis medullosis vel ligneis, demum loculosis, 0.1 - 0,6 mm crassis praedita.Perithecia obovoidea vel lanceolata, 0.5 - 1.2 mm alta x 0.2 - 0.3 mm diam., Ostiola obsoleta.

Asci 165 - 325 µm longitudine tota, 10 - 11 µm crassi; partibus sporiferis 80 - 105 µm longitudine, stipitibus 130 - 220 µm longitudine, annulo apicali discoideo, 0.8 - 1 µm alto, x 3 - 3.5 µm crasso, in liquore iodato Melzeri cyanescente. Ascosporae brunneolae, unicellulares, ellipsoideo-equateriales vel ellipsoideo-inequateriales, apicibus angustatis, (13-)14 -15.5(-16.5) x 7-8 µm, rima germinativa recta, longa in latere convexo praeditae; perisporium in KOH dehiscens, leve, episporium leve.

Stromata subsessile or with stout stipe, 10 - 25 mm high x 10 - 25 mm diam, with inconspicuous perithecial mounds, surface reddish brown, blackened in age, with red granules immediately beneath the surface, with KOH extractable pigments isabelline (65), sepia (63), umber (9), or fuscous black (104), the tissue between perithecia pithy to woody, the tissue between the perithecial layers composed of alternating concentric zones, the darker zones dark brown, persistent, 0,1 - 0,3 mm thick, the lighter zones greyish brown, pithy to woody, loculate in aged specimens, 0,1 - 0,6 mm broad (1.5 -



Figs. 1- 4. Stromatal habitus of *D. pyrenaica*: **1)** HOLOTYPE (M), semiglobose stroma; **2)** HOLOTYPE (M), turbinate stroma; **3)** HOLOTYPE (M), aggregated stromata; **4)** Ww 3290 (ZT), fertile stroma showing prominent perithecial mounds. Photos by S. Woike. Scale is indicated by bars.

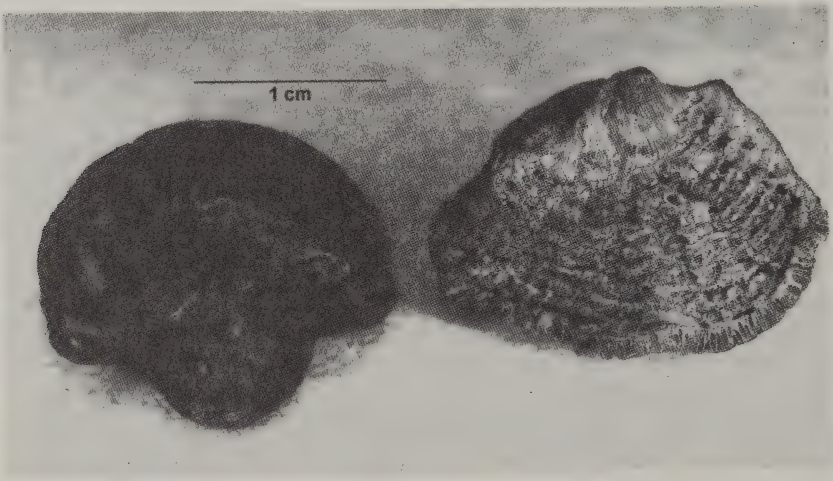


Fig. 5. Stromatal habitus of ***D. steglichii*** (HOLOTYPE, K.). Photo by S. Woike. Scale is indicated by bars.

3 times broader than the darker ones). Perithecia lanceolate or obovoid, 0.5 – 1.2 mm high x 0.2 x- 0.3 mm diam. Ostioles inconspicuous, obsolete.

Asci 165 - 325 µm total length, 10 - 11 µm broad, the spore-bearing part 80 - 105 µm long, the stipe 130 - 220 µm long, with apical ring 0.8 - 1 µm high x 3 - 3.5 µm broad, bluing in Melzer´s iodine reagent. Ascospores brown, unicellular, ellipsoid-equilateral (shape reminding of a Rugby ball) or ellipsoid-inequaterial with narrowly rounded ends, (13-)14 -15.5(-16.5) x 7 - 8 µm, germ slit straight, on the more convex side of the spore, perispore dehiscent with 10% KOH, smooth, epispore smooth (as seen under the light microscope). Faint transversal striations become visible at larger magnifications under the SEM (Fig. 19).

CULTURES AND ANAMORPH Colonies on 2% Difco Oatmeal agar at 23°C and under 12h of fluorescent light reaching the edge of a 9 cm petri dish in 7-8 days, felty, zonate, with diffuse margins, at first whitish to pale yellow, becoming floccose and brown when sporulating, reverse yellow-greenish, blackening with age, releasing orange-brownish exudates into the agar, developing a sweet odour. Sporulating regions at first appearing on the margins of the colony, later scattered over entire surface of the colony. Conidiophores reaching a maximum height of up to 180 µm, mostly clustered together in synnematous structures (less frequently mononematous), dichotomously or (sometimes) trichotomously branched, hyaline, smooth or finely roughened, 2,5 - 3 µm diam, with one conidiogenous cell arising from each terminus, showing a ***Periconiella***-like or, less frequently, a ***Nodulisporium***-like branching pattern as defined in Ju and Rogers (1996). Conidiogenous cells cylindrical, hyaline, smooth, 12 - 20 x 2.5 - 3.5 µm. Conidia produced holoblastically from sympodially proliferating conidiogenous cells, hyaline, obovoid, smooth or finely roughened, (5.5-)6 - 7.5(-8) x 3.5 - 4,5(-5) µm.

SPECIMENS EXAMINED: INDIA: West Bengal, Chattari Chombz, 30. VIII. 1966, K(M) 78833, Thind 7239, as ***Daldinia bakeri*** (HOLOTYPE, K.), Ww 3793; Ustar Pradesh: Mussorii, 29. IX. 1965; trunk of ***Quercus***, (1800 m of altitude), Malhotra, C.L. No. 274 (L.), L. 0275630, Ww 3787.

[ADDITIONAL MATERIAL :PAPUA NEW GUINEA: Western Highlands Province, Kubor range, Uinba, wood, 23.8.1963, Vink, W. No. 16355, culture obtained from a specimen previously described by Van der Gucht (1994), deposited as ***D. grandis*** Child, MUCL 38739].

NOTES: This species was first described by Van der Gucht (1994) from Papua New Guinea as ***Daldinia*** *cf.* ***grande***. This name actually should refer to ***D. grandis*** Child. However, we found that authentic materials of ***D. grandis*** from New Zealand and Mexico (first reported by Ju et al., 1997), respectively, did not correspond with the specimens from India and the culture deposited with MUCL. ***D. grandis*** is not yet known from Asia. Moreover, this species is characterised by, e.g., much larger ascospores (which are actually smooth even under the SEM as can be seen in Fig. 20), and by an anamorph with a ***Virgariella***-like branching pattern in culture (Ju et al. 1997). ***D. grandis*** is further characterised by purple stromatal pigments in KOH, due to the presence of BNT, and by the absence of benzophenones and azaphilones as stromatal pigments. Accordingly, the genetic fingerprints of ***D. steglichii*** were also different from the ones of ***D. grandis*** (Stadler et al., 2001b*)*. The minisatellite PCR pattern of ***D. steglichii*** was rather similar to those typically observed in ***D. childiae***, while the ARDRA patterns of both species differed (Stadler et al., 2001b). Interestingly, the culture deposited at MUCL produced ***Periconiella***-like conidiophores on Difco OA media, similar to the culture of ***D. mexicana*** described by Ju et al. (1999). Synnematous structures as seen in the cultures of this species had previously been reported to occur occasionally in cultures of ***D. eschscholzii*** (Ju et al., 1997) and were so far not encountered in any other species of the genus examined by us. It should also be pointed out that these structures are not frequently formed by ***D. steglichii***, e.g., in YMG cultures, where production of conidiophores is rather sparse.

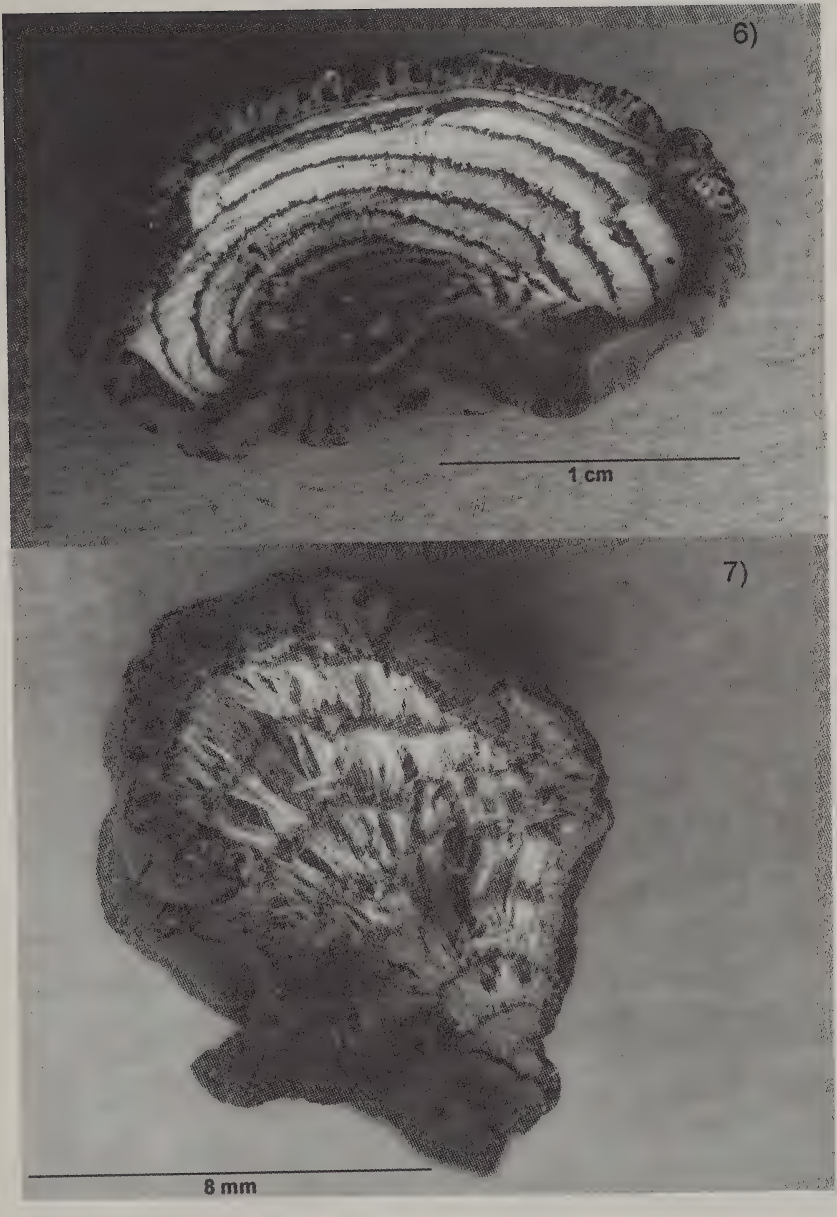
The material from Papua New Guinea was not located at L. However, Van der Gucht (1994) had also reported another collection from India to correspond well with her species from Papua New Guinea, and this specimen was still extant at K. Our morphological studies of this material (herein referred to as Ww 3793), including SEM of ascospores, shape and size of conidiophores and conidia on the stromatal surface generally confirmed the observations by Van der Gucht (1994). Out of several further specimens sent to us from L., we found another collection from India (Ww 3787) to be in full correspondence with Ww 3793. We consider this taxon to be a new species and selected the material deposited at K. as holotype.

In the methanolic stromatal extracts of ***D. steglichii***, different metabolites profiles as compared with the ones of ***D. childiae*** was observed, despite their similar stromatal pigment colours in KOH. The benzophenone, daldinal A, was the prevailing metabolite. Azaphilones of the daldinin type (which are omnipresent main metabolites in ***D. childiae*** and ***D. pyrenaica***) were not detected in ***D. steglichii***. Still, the presence of daldinals in ***D. steglichii*** confirmed morphological similarities, pointing toward a close relationship between the three before mentioned species. ***D. steglichii*** has larger ascospores than ***D. childiae***. SEM of the ascospores of ***D. steglichii*** also revealed that a very dense, less transparent perispore layer covered the ascospores. Therefore, the transversal striations of the epispore appeared less conspicuous than in other ***Daldinia*** spp. with yellow stromatal pigments (Fig. 19). The rather unique characteristics of the anamorph as revealed from examination of the culture from Papua New Guinea deposited at MUCL further emphasised the status of ***D. steglichii*** as a previously undescribed species.

Daldinia albofibrosa M. Stadler, M. Baumgartner & Wollweber, *sp. nov.*
Figs. 6-7, 14, 18

[= ***Daldinia albozonata*** Van der Gucht, K., 1994. PH D Dissertation Univ. Gent pp. 115-117 and plates 19-21; Van der Gucht, K., 1995. Bull. Jard. Bot. Nat. Belg. 64: 219–403, p. 258 –260 and Figs. 10a-b, 11d-f].

ETYMOLOGY: Refers to the characteristic broad, white, fibrous zones of the entostroma.



Figs. 6-7. Stromatal habitus of ***D. albofibrosa*** (HOLOTYPE, GENT). Photos by S. Woike. Scale is indicated by bars.

Stromata subglobosa, subsessilia vel turbinata, solitaria vel gregaria, (5-) 10-20 mm diam x 15 - 25 mm alta, externe griseobrunnea vel brunnea-vinacea, denum denigrata, tumulis peritheciorum inconspicuis, sub superficie granulis rufo-brunneis, granulis isabellinis vel brunneis in KOH dissolutis; textura inter perithecia brunnea medulosa vel lignea, textura inter perthecia brunnea medullosa vel lignea, textura sub peritheciis zonis alternantibus composita, zonis atrobrunneis medullosis vel ligneis, 0.1 - 0.15 mm crassis et zonis albis medullosis vel ligneis, persistentibus, 0.8 - 1 mm crassis praedita. Perithecia obovoidea, 0.8 – 1 mm alta x 0.2 – 0.4 mm diam. Ostiola obsoleta.

Asci 110 - 150 µm longitudine tota, 6 - 7 µm crassi; partibus sporiferis 60 - 75 µm longitudine, stipitibus 50 - 75 µm longitudine, annulo apicali discoideo, 0.6-0.7 µm alto, x 2-2.5 µm crasso, in liquore iodato Melzeri cyanescente. Ascosporae brunneolae, unicellulares, ellipsoideo-inequateriales, apicibus angustatis (8.5-)9-10.5 x 4-4.5 µm, rima germinativa recta, longa in latere convexo praeditae; perisporium in KOH dehiscens, leve, episporium leve.

Stromata subglobose, subsessile or turbinate, (5-)10 - 20 mm diam x 10-25 mm high, solitary or gregarious, without conspicuous perithecial mounds, surface greyish brown to vinaceous brown (84), with red granules immediately beneath the surface, with KOH extractable pigments umber (9), isabelline (65), fuscous black (104) to sepia (63), the tissue between perithecia pithy to woody, the tissue between the perithecial layers composed of alternating concentric zones, the darker zones dark brown, pithy to woody, 0.1 - 0.15 mm thick, the lighter zones white, pithy to woody, persistent, 0.8 - 1.5 mm thick, at least four times and up to 6 - 10 times broader than the darker ones. Perithecia mostly monostichous, lanceolate, 0.8 - 1 mm high x 0.2 - 0.4 mm diam (some obovoid polystichous perithecia in the lateral stromatal regions were observed). Ostioles obsolete.

Asci 110 - 150 µm total length, 6 - 7 µm broad, the spore-bearing part 60 - 75 µm long, the stipe 50 - 75 µm long, with apical ring 0.6 - 0.7 µm high x 2-2.5 µm broad, bluing in Melzer´s iodine reagent. Ascospores brown, unicellular, elongate ellipsoid-inequaterial with narrowly rounded ends, (8.5-)9 - 10.5 x 4 - 4.5 µm, germ slit straight, on the more convex side of the spore, perispore dehiscent with 10% KOH, smooth, epispore smooth (as seen under the light microscope). Faint transversal striations were observed by SEM (Fig. 18).

CULTURES AND ANAMORPH: Colonies on 2% Difco Oatmeal agar at 23 °C and under 12h of fluorescent light reaching the edge of a 9 cm petri dish in 10 days, felty, zonate, with diffuse margins, at first whitish to pale yellow becoming floccose and greyish brown when sporulating, reverse yellow-greenish, blackening with age, releasing greenish to brownish exudates into the agar, developing a sweet odour. Sporulating regions at first appearing in the centre of the colony, later scattered over entire surface of the colony. Conidiophores reaching a maximum height of 210 µm, mononematous, dichotomously or (sometimes) trichotomously branched, hyaline, smooth or finely roughened, 2.5 - 3 µm diam, with one conidiogenous cell arising from each terminus, showing a ***Nodulisporium***- like branching pattern as defined in Ju and Rogers (1996). Conidiogenous cells terminal or intercalary, cylindrical, hyaline, smooth, 10 -16 x 2 – 2.5 µm. Conidia produced holoblastically from sympodially proliferating conidiogenous cells, hyaline, obovoid, smooth or finely roughened, 4-6 x 2-3 µm.

NOTES: This fungus was described by Van der Gucht (1994) as ***D. albozonata*** Lloyd which is an invalid synonym of ***D. clavata*** Henn., according to Ju et al. (1997), who found that all specimens they investigated from Africa, Central and South America (including the holotype) yielded none or purplish stromatal pigments. On the other hand, Van der Gucht (1994) found her collections from Papua New Guinea "corresponded very well with the holotype from Cameroon". The anamorphic structures of ***D. clavata*** resemble those of ***D. eschscholzii***, i.e., the conidiophores are rather small, showing a ***Nodulisporium***-like branching pattern (Ju et al., 1997). In accordance with Ju et al. (1997), all materials of ***D. clavata*** we studied from Liberia, Argentina, Cuba and Mexico showed consistent characters, while a corresponding culture of ***D. albozonata*** deposited with MUCL formed more robust conidiophores and larger conidia than ***D. clavata*** and even differed in its genetic fingerprints (Stadler et al., 2001a, 2001b). To explain these discrepancies, the teleomorphic materials deposited by Van der Gucht were obtained from GENT and re-examined. This type material was also cultured despite the fact that it had been collected several years ago. The morphological description by Van der Gucht (1994) was basically in accordance with our own observations. In contrast to Van der Gucht, we observed that the stromata from Papua New Guinea were smaller and were lacking a prominent stipe altogether. However, both aforementioned species are characterised by having rather broad white internal zones, and the ascospores of Van der Gucht´s materials showed about the same size range and shape as typically observed in ***D. clavata***.

Like in ***D. steglichii***, the stromata of ***D. albofibrosa*** yielded yellowish KOH-extractable pigments and contained daldinal A but no daldinin as main metabolites. In contrast to these findings, the stromatal pigments of ***D. clavata*** from Africa, the Carribbean, and South America were purple, due to the presence of BNT (see also Stadler et al. 2001a). Another difference between ***D*. *albofibrosa*** and ***D*. *clavata*** was found during ultrastructural studies of their ascospores. Notably, Van der Gucht (1994) did not explicitly state she had examined the ascospores of the holotype from Cameroon by SEM in comparison with her ***D. albozonata*** and also did not depict SEM microphotographs of their ascospores. In agreement with Van der Gucht (1994), we observed transversal striations in the ascospores of her specimens from Papua New Guinea, whereas those of ***D. clavata*** were smooth by SEM (compare Figs 17 and 18).

The cultures of the Asian taxon were similar to the ones we obtained from America with respect to their branching patterns and size of their conidia. However, as depicted in Fig. 13, the hyphae and conidiophores of ***D. clavata*** were hyaline but frequently covered with droplets of pigmented exudates, while the conidiophores of ***D. albofibrosa*** (Fig. 14) were finely roughened but did not excrete any exsudates.

These results justify the separation of the Asian taxon from ***D. clavata***. Possibly, ***D. clavata*** represents the Afro-American counterpart of the Asian ***D. albofibrosa***. Both species might be derived from a pantropical ***Daldinia*** spp. as common ancestor in the course of divergent evolutionary processes.

SPECIMENS EXAMINED: PAPUA NEW GUINEA: Madang Province, lowland rain forest, wood, 20.X.1989, Van der Gucht. K. 89-924 (HOLOTYPE, G.), CULTURED, Ww 3777; Madang Province, forest border, on small log, 6.IX.1990, Van der Veken, P. 90-687 (GENT), Ww 3776.

[ADDITIONAL MATERIAL: Culture of strain MUCL 38738, deposited as ***D. albozonata*** Lloyd with MUCL, Belgium, corresponding with either Ww 3777 or Ww 3776].

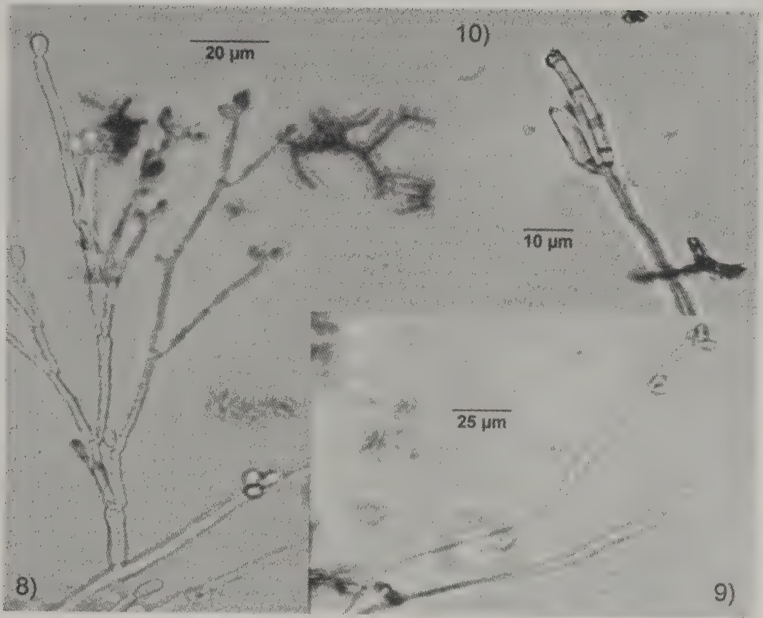
Further yet unnamed *Daldinia* spp. with yellow stromatal pigments

Among the specimens of ***Daldinia*** spp. we studied were several ones showing yellowish pigments in KOH, due to the presence of azaphilones (daldinins) and/or benzophenones (daldinals) as revealed by HPLC analyses. However, their stromata were found devoid of ascospores and other teleomorphic characters, and we did not obtain cultures from any of these collections. We suspect that the materials were collected at a premature stage of development. It remains to be established whether they correspond with any of the known yellow-pigmented European ***Daldinia*** spp. (***D. childiae, D. pyrenaica***). These specimens are listed below. Collections from the same geographic regions should be checked for stromatal pigments and the presence of teleomorphic characters.

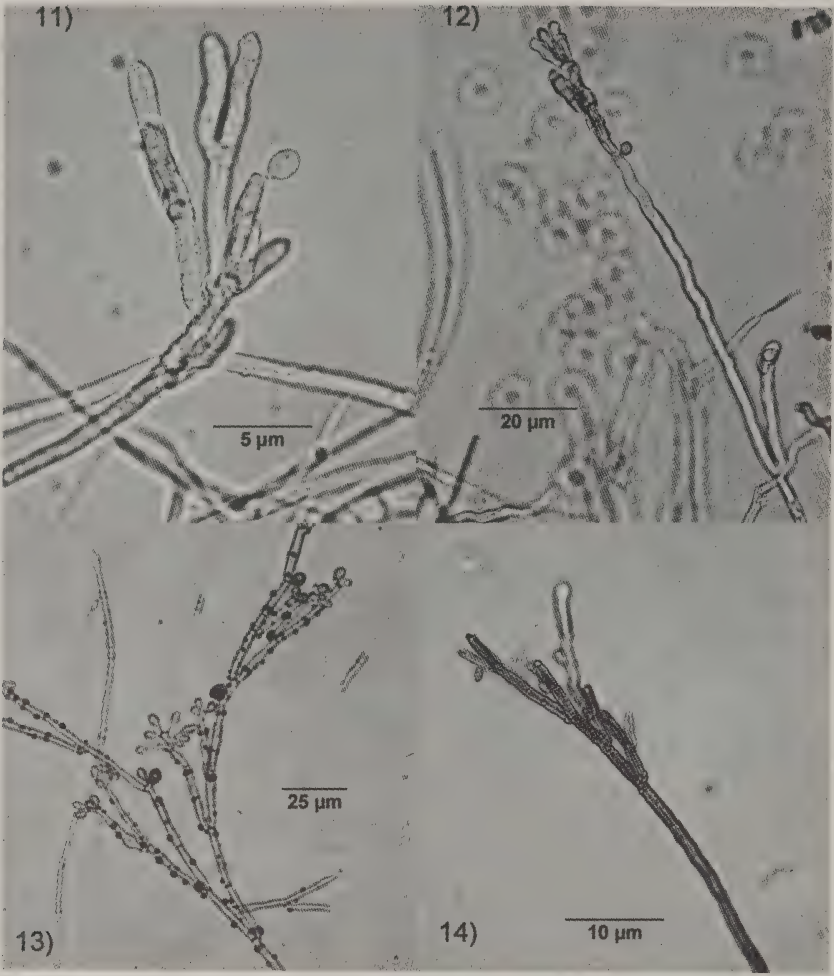
SPECIMENS EXAMINED: GERMANY: Lower Saxony Province, near Naturschutzgebiet Steinberg, 22.XI.1998, ***Salix rubens*** (***S. fragilis* x *alba***), Wöldecke, K. 981122., Ww 3519; North Rhine Westphalia Province, Goldgosse near Bielefeld, 25.III.1979, ***Salix***, leg. I. & W. Sonneborn, Ww 2993; Saxony Province, Leipzig, Zweinaudorfer Park, 22.VIII.1963, ***Ulmus***, Kreisel, H., Ww 3839; Bavaria Province, Franconia District, Grettstadt, 22.IV.1995, ***Carpinus***, Krieglsteiner, L., WU 1596 (R.), Ww 3817.

CONCLUSION

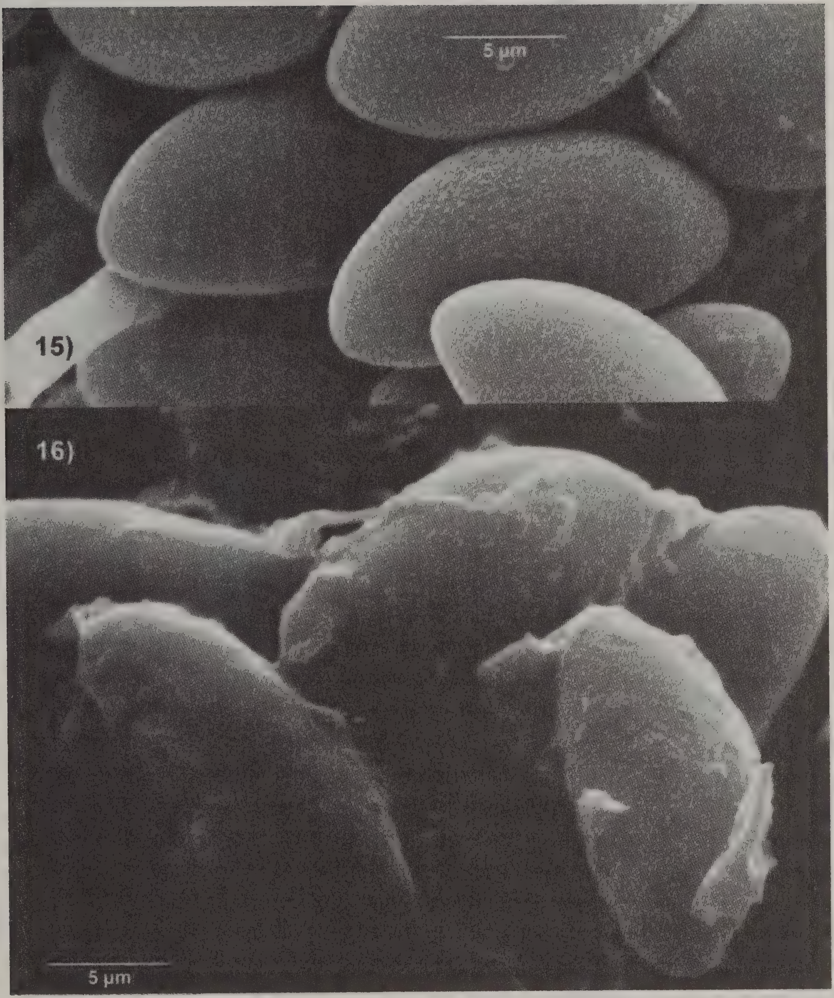
Three “cryptic species” containing similar stromatal pigments and secondary metabolites as ***D. childiae*** were encountered upon intensified evaluation of previous collections. The delimitations of these species from previously described taxa by traditional morphological studies were supported and confirmed by means of ultrastructural and molecular data. The importance of KOH-extractable stromatal pigments as a diagnostic tool introduced by Ju et al. (1997) for discrimination of ***Daldinia*** on the species level is further emphasised by these results. Possibly, several further previously collected ***Daldinia*** spp. (especially such ones from tropical countries) will soon be reclassified on the basis of the currently employed methodology.



Figs. 8-10. Anamorphic structures of ***Daldinia pyrenaica*** (from ex-type culture): **8)** ***Nodulisporium***-like conidiophores (phase contrast, 400x); **9)** ***Sporothrix***-like conidiophores (phase contrast, 1000x); **10)** conidiogenous cells, (phase contrast, 1000x). Scale is indicated by bars.


11)
5 µm
12)
20 µm
13)
25 µm
14)
10 µm

Figs. 11-14. Microphotographs (phase contrast) from cultures of ***Daldinia*** spp. **11)** ***D. childiae*** Ww 3715 (Switzerland, 1000x); **12)** ***D. steglichii*** (MUCL culture, 400x); **13)** ***D. clavata*** Ww 3728 (Argentina, 400x); **14)** ***D. albofibrosa*** (Ex-HOLOTYPE (400x). Scale is indicated by bars.



Figs. 15-20 (SEM microphotographs of ascospores of several ***Daldinia*** spp.).
15) ***Daldinia pyrenaica*** (from HOLOTYPE); **16)** ***D. childiae*** (Ww 3587 from France).
Magnification: 5.000x. Scale is indicated by bars.

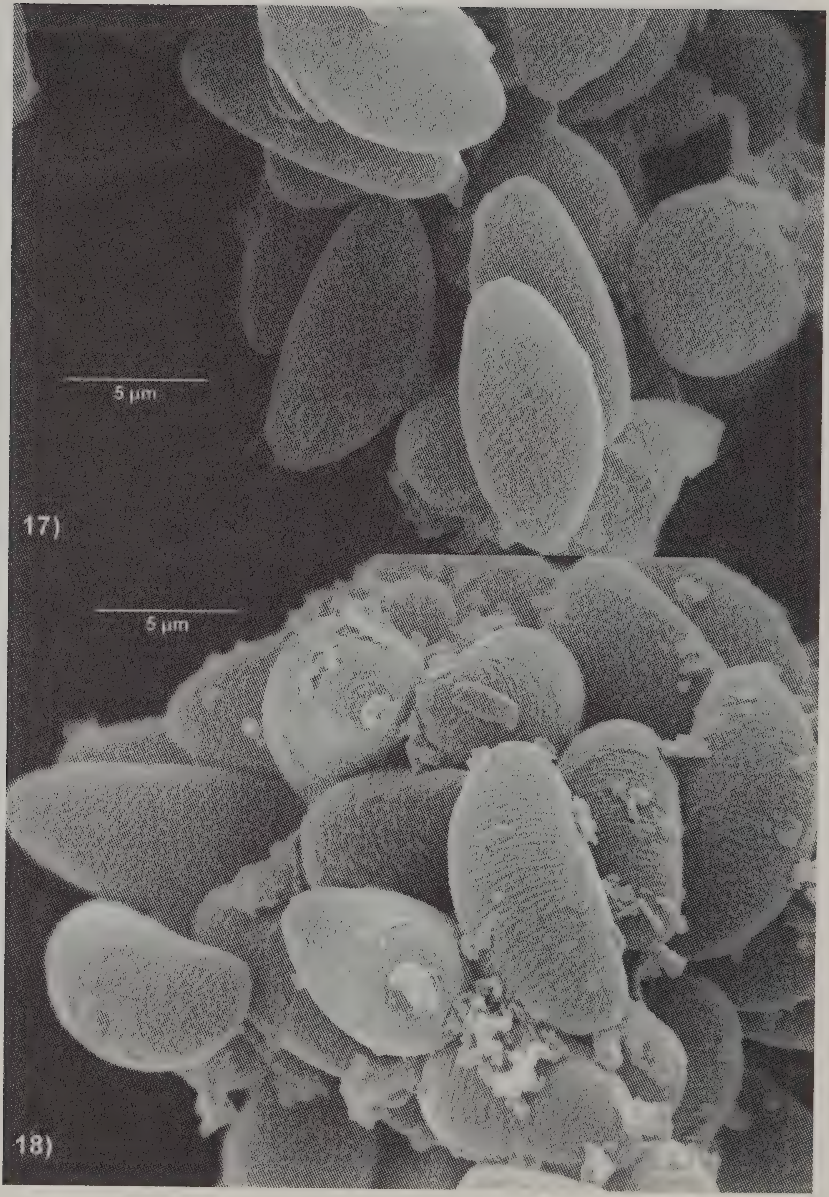
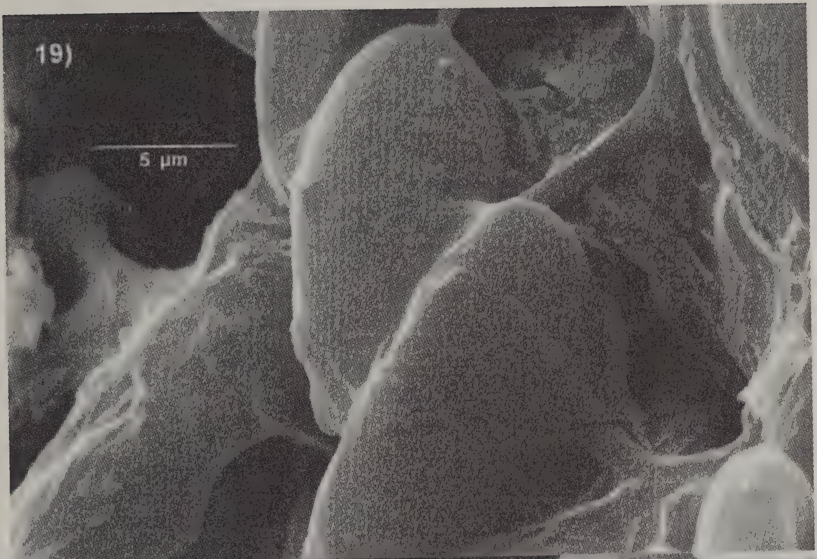
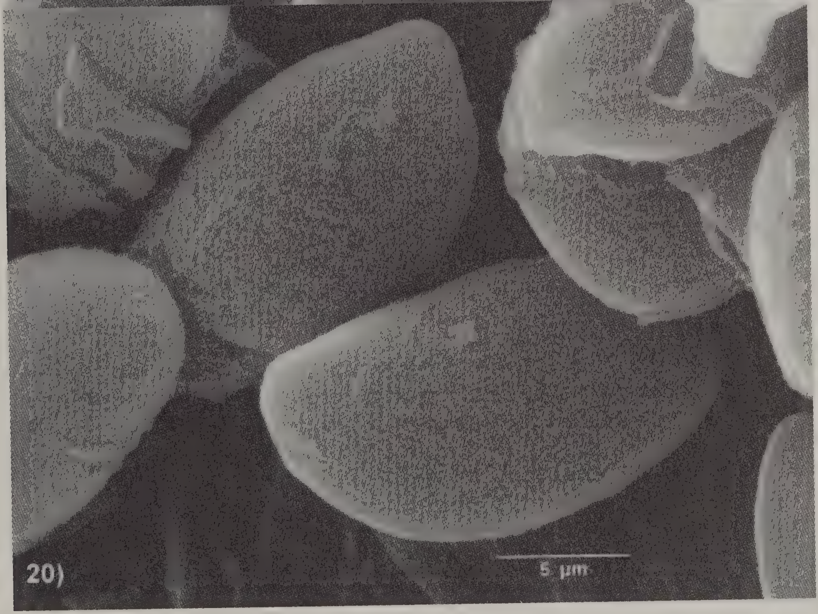


Fig. 15-20 (SEM microphotographs of ascospores, continued). **17)** ***Daldinia clavata*** Ww 3728 (from Argentina); **18)** ***D. albofibrosa*** (from HOLOTYPE). Magnification: 10.000x. Scale is indicated by bars.





Figs. 15-20 (SEM microphotographs of ascospores, continued). **19)** ***Daldinia steglichii*** (from HOLOTYPE); **20)** ***D. grandis*** (Mexico, see Ju et al. 1997). Magnification: 5.000x. Scale is indicated by bars.

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A NEW SPECIES OF SPHAEROSPORELLA FROM TAIWAN

Yei-Zeng Wang
National Museum of Natural Science, Taichung, Taiwan 404, R. O. C.
E-mail: yzwang@mail.nmns.edu.tw

ABSTRACT: This paper describes and illustrates a new species, *Sphaerosporella taiwania,* collected on soil under *Pinus taiwanensis* in Taiwan. It differs from *S. brunnea* and *S. hinnulea* mainly by the smaller ascospores.

KEYWORDS: *Dichobotrys,* Otideaceae, Pezizales, *Pinus, Trichophaea.*

Sphaerosporella taiwania Y. Z. Wang, sp. nov. (Figs. 1, 2.)
Apothecia gregaria, sessilis, 1-5 mm diam., discus concavus, luteolus vel brunnescens cum annosus. Receptaculum subbrunneum, coopertum ad brevie brunneum pilis, ad marginatum imprimis. Pipi 1-3 septata, brunnea tunicata, 40-55 x 7-9 µm. Excipulum ectale textum globosum vel polygonium cellularis, 20-50 µm diam., stratum 150-200 µm crassum. Excipulum medullosae textum intricatum, 5-7 µm diam, stratum 50-150 µm crassum. Hymenium stratum luteolum, 240-260 µm crassum. Asci 8-spori, 4-6 spori raro, cylindricum, 150-185 x 14-19 um, basis ad a crozier. Ascosporae uniseriatae, hyalinae, leaves, globosae, 10-13 µm. Paraphyses filiformes, septatae exigue, basis 2-3 µm diam, vel apice leviter inflati, 4-6 µm diam. Anamorphosis Dichobotrys.

Holotypus: Taiwan, Taichung: National Museum of Natural Science, 18.V. 1999, WAN 663 (TNM).

Apothecia gregarious, sessile, 1-5 mm diam., disc concave, yellowish orange turning to brown when older. Receptacle pale brown, covered by short brown hairs, especially towards the margin, hairs 1-3 septate, brown walled, apex pointed, 40-55 x 7-9 µm. Ectal excipulum composed of globose to polygonal cells, 20-50 µm diam., layer 150-200 µm thick, medullary excipulum of *textura intricata*, layer 50-150 µm thick, hyphae loosely arranged, 5-7 µm wide. Hymenium layer yellowish, 240-260 µm thick. Asci 8-spored, occasionally 4-6-spored, cylindrical, 150-185 x 14-19 µm, with a crozier at base.

Ascospores uniseriate, hyaline, smooth, globose, 10-13 μm diam., each with a large droplet, some appearing to be covered by a loose coating. Paraphyses filiform, base 2-3 μm, enlarged at tips to 4-6 μm wide, sparingly septate, filled with yellowish brown granules. Anamorph *Dichobotrys.*

The single-ascospore cultures were isolated from specimen *WAN 832.* Colonies on MEA medium spreading rapidly, reaching 9 cm diam. in 7 days at room temperature. Mycelium loose, floccose, white to yellowish brown; hyphae 6-8 μm diam., sparingly septate. Conidiophores erect, appearing after 2 weeks on CMA medium, conidia hyaline to light brown, globose to subglobose, 12-14 μm diam.

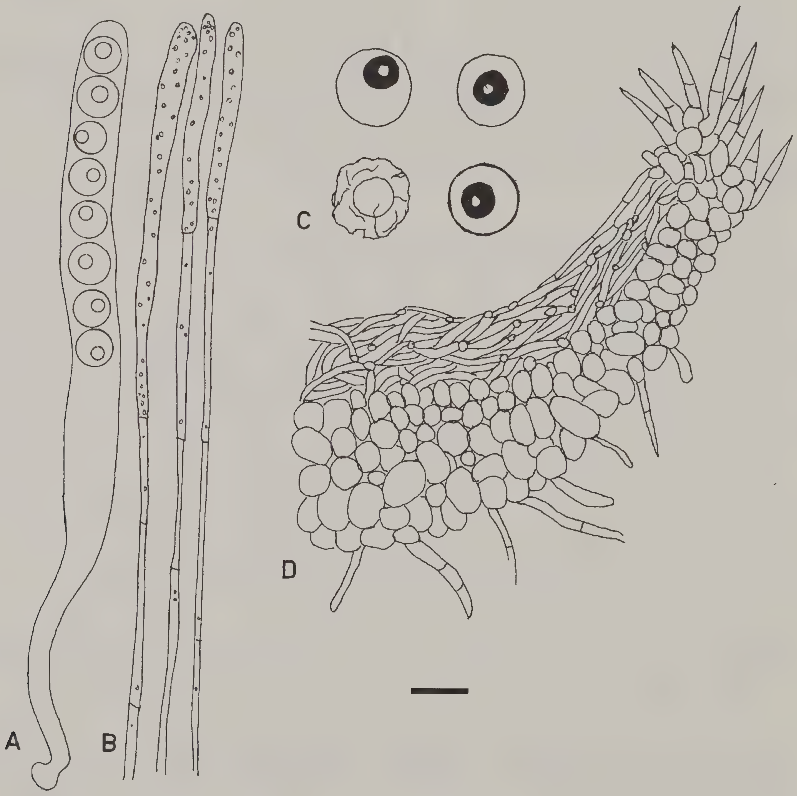

Fig. 1. *Sphaerosporella taiwania* (holotype) A. An ascus. B. Paraphyses. C. Ascospores. D. A part of the receptacle. Bar = 15.6 μm for A and B; 10 μm for C; and 50 μm for D.

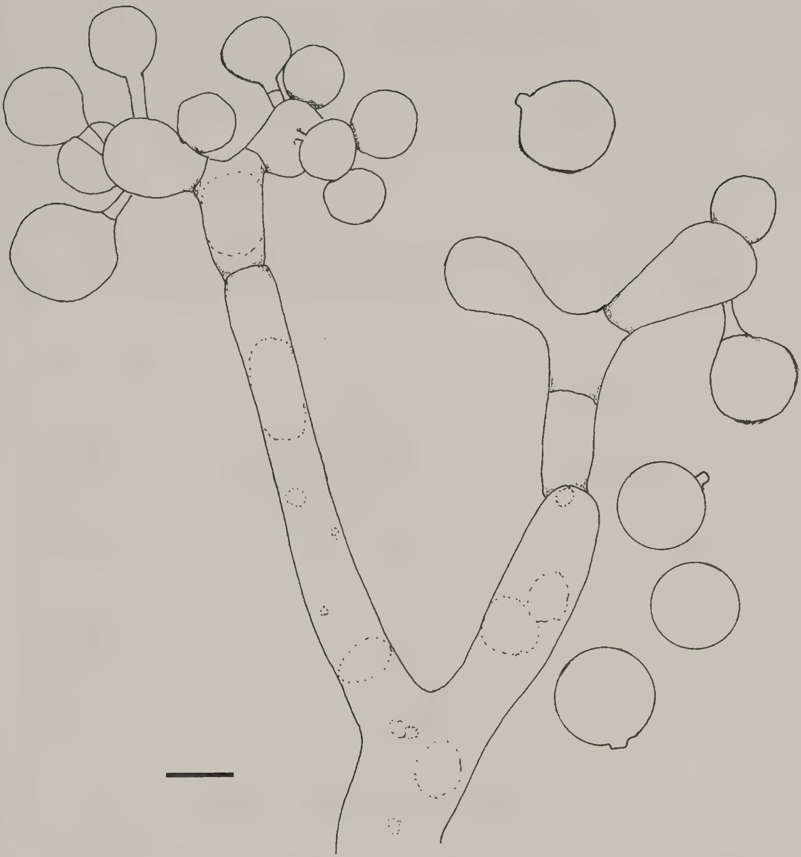

Fig. 2. Conidial state of *Sphaerosporella taiwania (WAN 832).* Conidiophore and conidia. Bar = 10 μm.

Holotype: Taiwan. Taichung: National Museum of Natural Science, on soil under *Pinus taiwanensis*, May 18, 1999, coll. *W. N. Chou; WAN 663* (TNM).

Additional specimen examined: Taiwan. Taichung: National Museum of Natural Science, on soil under *Pinus taiwanensis*, Apr. 24, 2000, coll. *Y. Z. Wang; WAN 832* (TNM).

Etymology: Latinized from Taiwan; locality of the type collection.

This species is similar to *S. brunnea* by the small, yellowish-brown, hairy apothecia and globose ascospores but the latter usually grows on burnt ground, the apothecia are not brightly colored, and the ascospores are larger (13-16 μm in Rifai, 1968; 13.3-16.2 μm in Häffner, 1987). *Sphaerosporella hinnulea* also grows on soil, but has larger apothecia and ascospores (Rifai, 1968; Seaver, 1978). Yao and Spooner (1996) treated *S. hinnulea* as a synonym of *S. brunnea*. Korf (1972) has merged *Sphaerosporella* with *Trichophaea*, hence he will assign this species to *Trichophaea* (Korf, *pers. comm.*). Cain and Hastings (1956) isolated *Sphaerospora minuta* from sandy soil collected in a forest of *Pinus banksiana*. It also has brown, hairy apothecia with smooth, globose ascospores, that are 13-17 μm and a conidial state of *Dichobotrys,* and was transferred to *Trichophaea* by Korf (Hennebert, 1973). Since *Sphaerosporella brunnea* is capable of forming ectomycorrhizae with *Pinus banksiana* (Danielson, 1984), the relationships between *S. taiwania* and *Pinus taiwanensis* await for further studies.

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NEW AND RARE SPECIES OF LASIOSPHAERIA IN SOUTHWESTERN FRANCE

Françoise CANDOUSSAU[1], Jacques FOURNIER[2], Jean-François MAGNI[3]
[1] : 53, rue A. Briand, F- 64000 Pau, France
[2] : Las Muros, F-09420 Rimont, France
[3] : 13, rue de la Calvette, F-31750 Escalquens, France
E.mail:jfmagni@club-internet.fr

Abstract. Five new species of *Lasiosphaeria* are described and illustrated on material from Southwestern France, i.e. *L. capitata, L. pallida, L. rufa, L. vestita and L. volvestriana*. Eight other species, i.e. *L. breviseta, L. caudata, L. immersa, L. moseri, L. munkii, L. punctata, L. pyramidata* and *L. stuppea* are recorded from France for the first time, of which *L. punctata, L. pyramidata* and *L. stuppea* are described in detail. New French records of *L. porifera* are given.

Key words: Ascomycotina, Sordariales, Lasiosphaeriaceae, wood-inhabiting fungi, systematics.

Introduction

Several rare and new species of *Lasiosphaeria* Ces. & de Not. were collected in four departments of Southwestern France: Pyrénées Atlantiques (FC), Gironde and Haute Garonne (JFM) and Ariège (JF)[1]. These collections were made mostly in deciduous forests, more rarely in mixed forests, ranging from 50 to 850 m a.s.l. (only once at 1400 m a.s.l.), all characterized by high humidity and mild temperature. Southwestern France is a north temperate area under oceanic influence where the relief induces a high diversity in seminatural ecosystems and where a high biodiversity can be expected. The purpose of our work is to illustrate its high fungal diversity on the example of the lignicolous ascomycete genus *Lasiosphaeria*.

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[1] - Collectors names are abbreviated as follows: FC (Françoise Candoussau), JF (Jacques Fournier), JFM (Jean François Magni) and herbarium numbers following these abbreviations refer to authors' private herbaria.

A generic concept of *Lasiosphaeria* and its delimitation has been discussed in several recent publications (Carroll & Munk 1964, Lundqvist 1972, Hilber & Hilber 1979, Réblová 1999). In all of them, *Lasiosphaeria* is conceived as a broadly delimited genus with high variability in perithecial vestiture, peridium anatomy and ascospore morphology that leads to an obvious heterogeneity. We attempted to use such characters, mainly noncorrelated, in order to propose morphologically distinct groups within the genus, however, it would only lead to create artificial groups. A more natural subgeneric classification should be based on anamorphic data, but unfortunately ascospores of *Lasiosphaeria* germinate very slowly under usual cultural conditions and cultures are often contaminated before isolated ascospores germinate (Réblová, in lit., JF 26/10/00), and we are not aware of reports of any species of *Lasiosphaeria* having been cultured, except *L. hirsuta* (Fr.) Ces. & de Not. and *L. ovina* (Pers. : Fr.) Ces. & de Not., anamorphs of which have been assigned to *Phialophora* (Gams & Holubová-Jechová 1976). For these reasons culture of none of the species has been attempted. In natural conditions only one species, *L. punctata* Munk, was regularly found growing with associated *Endophragmiella* and S*elenosporella*-like synnanamorphs (Hughes 1979, Sivanesan 1983). Hughes (1979) reported two collections of *L. canescens* (Alb. & Schwein. : Fr.) Sacc. being associated with *Endophragmiella* and *Selenosporella*-like conidiogenous cells produced by discharged ascospores and we also observed, occasionally*, L. strigosa* (Pers. : Fr.) P. Karst. and *L. rufa* sp. nov. being associated with *Endophragmiella* conidiophores and conidia, but this relation remains a supposition (see discussion on *L. punctata).* The scanty information about lasiosphaeriaceous anamorphs does not yet allow to go further into a subgeneric splitting of the genus *Lasiosphaeria.* As long as definite criteria do not delimit the genus *Lasiosphaeria*, the five new species are considered to belong to it on account of the distinctive features that they share with representative species such as *L. ovina,* the type species, *L. strigosa, L. breviseta* P. Karst. and *L. moseri* O. Hilber, and their peculiarities illustrate well the complexity and heterogeneity within the genus.

A key to lignicolous species of *Lasiosphaeria*, including five new species, is proposed here. We excluded from this key several species originally placed in the genus *Lasiosphaeria* that were transferred by previous authors to other genera listed as follows:
Acanthostigma De Not.: *L. minuta* Fuckel, *L. scleracantha* Sacc. = *A. minutum* (Fuckel) Sacc., *L. scopula* (Cooke & Peck) Sacc. = *A. scopulum* (Cooke & Peck) Peck, (Réblová & Barr 2000).

See Errata

Byssosphaeria Cooke: *L. cirrhostoma* (Berk. & Br.) Sacc. = *L. keitii* (Berk. & Br.) Berl. = *B. schiedermayeriana* (Fuckel) Barr; *L. xestothele* (Berk. & Curtis) Sacc. = *B. xestothele* (Berk. & Curtis) Barr, (Barr 1984).

Cercophora Fuckel: *L. ambigua* Sacc. = *C. ambigua* (Sacc.) R. Hilber ; *L. ambigua* Sacc. var. *carbonaria* (Phill. & Plowr.) Rehm = *C. arenicola* R. Hilber; *L. newfieldiana* Ellis & Everh. = *C. newfieldiana* (Ellis & Everh.) R. Hilber; *L. solaris* (Cooke & Ellis) Sacc. = *C. solaris* (Cooke & Ellis) R. & O. Hilber; *L. sulphurella* Sacc.= *C. sulphurella* (Sacc.) R. Hilber, (Hilber & Hilber 1979).

Chaetosphaeria Tul. & C. Tul.: *L. britzelmayri* Sacc. subsp. *fennica* P. Karst. = *C. fennica* (P. Karst.) Réblová & W. Gams, (Réblová & Gams 1999); *L. ineaqualis* (Grove) Massee = *Chaetosphaeria inaequalis* (Grove) Gams & Hol.-Jech., (Gams & Holubová-Jechová 1976, Réblová & Winka 2000).

Eosphaeria von Höhnel: *L. dichroospora* Ellis & Everh.= *E. uliginosa* (Fr.) von Höhnel (L. Petrini et al. 1984).

Herpotrichia Fuckel: *L. scabra* Auersw. = *H. juniperi* (Duby) Petrak; *L. macrotricha* (Berk. & Br.) Cooke = *H. macrotricha* (Berk. & Br.) Sacc.; *L. scabra* (Currey) Sacc. = *L. scabra* (Currey) Massee = *H. macrotricha* (Berk. & Br.) Sacc, (Barr 1984).

Lasiosphaerella A. Sivan.: *L. noonae-daniae* Carroll & Munk = *L. noonae-daniae* (Carroll & Munk) A. Sivan., (Sivanesan 1975); *L. pseudobombarda* (Mont.) Berl. = *L. pseudobombarda* (Mont.) Huhndorf & Fernández, (Huhndorf & Fernández 1999).

Melanopsammella Höhnel : *L. inaequalis* (Grove) Massee = *M. inaequalis* (Grove) Höhnel, (Réblová et al. 1999).

Miyoshiella Kawamura : *L. triseptata* Shoemaker & White = *M. triseptata* (Shoemaker & White) Réblová; (Shoemaker & White 1985; Réblová 1999).

Neopeckia Saccardo : *L. coulteri* (Peck) Ellis & Everh. = *L. acicola* Cooke = *N. coulteri* (Peck) Sacc., (Barr 1984).

Pseudotrichia Kirschstein: *L. mutabilis* (Pers. :Fr.) Fuckel = *L. viridicoma* (Cooke & Peck) Sacc. = *P. mutabilis* (Pers. :Fr.) Wehmeyer, (Barr 1984).

Tubeufia Penzig & Saccardo : *L. helicoma* (Phill. & Plowr.) Sacc. = *L. nematospora* Linder = *T. helicoma* (Phill. & Plowr.) Pirozynski; *L. pezizula* (Berk. & Curtis) Sacc. = *T. pezizula* (Berk. & Curtis) Barr, (Barr 1980).

Umbrinosphaeria Réblová: *L. caesariata* (Clinton & Peck) Sacc. = *U. caesariata* (Clinton & Peck) Réblová, (Réblová 1999).

We also omitted *L. coacta* Kirschstein as, according to Munk (1957) and to our own observations of both teleomorph and anamorph characters it could be transferred to *Helminthosphaeria* Samuels et al.; *L. ferruginea* Fuckel (Fuckel,1870) (GERMANY. Neuhof near Hattenheim, on *Sorbus domestica*, Spring, no 668, ex Herbarium Fuckel, Fungi rhenani 2172, FH, type) the type of which was examined, which is not a *Lasiosphaeria* regarding its dark brown several septate, broadly fusiform ascospores provided with pale end cells; *L. gibberosa* Munk (according to Munk (1957) himself, its position in this genus is doubtful) and *L. heterotricha* Munk (BPI-623998) that should be transferred to *Phaeotrichosphaeria* Sivanesan (G.J. Samuels, personal communication). We have not retained among the 131 species of *Lasiosphaeria* listed in the Index to Saccardo's Sylloge Fungorum (Reed & Farr, 1993) those that are poorly known, whose original description is too scanty and lacks precision concerning microscopic data, and the type of which should be examined on the occasion of a revision of the genus, especially checking whether asci are unitunicate or bitunicate. We finally kept in the key only the species that have been described with enough precision by their authors to be compared and distinguished from each other. We are aware that this choice is restrictive and should be emended in further studies by addition of other species, but the purpose of this key is to compare the five new species with those that we can currently accept in *Lasiosphaeria.*

Among the species newly recorded from France we chose to give a detailed description for three of them (*L. punctata, L. pyramidata* Carroll & Munk, *L. stuppea* Ellis & Everh.) whose original description could be completed by our own observations on fresh material. For the four remaining species *(L. breviseta, L. immersa* P. Karst., *L. moseri, L. munkii* R. & O. Hilber*)* and for *L. porifera* Réblová the reader is referred to the thorough descriptions given by Hilber & Hilber (1983), Hilber et al. (1987) and Réblová (1998).

Material and methods

Fresh specimens were studied in lactophenol, 3% KOH, lactic blue, Melzer's reagent, Congo red aq., phloxine or Waterman colored inks. Herbarium specimens were rehydrated in 3% KOH and rinsed in water before being treated as fresh specimens. Freehand sections of perithecial wall were made under the dissecting microscope either on dry material or on rehydrated material embedded in polyvinyl-lactophenol and observed in lactophenol or lactic blue (cf. (Van Brummelen 1967)). Drawings were made with the aid of a drawing tube on a Wild bright field microscope, and photographs taken with an Olympus camera. Ascospore measurements were taken on samples of 30 ascospores of each specimen, extreme values are given for length and width, in brackets are given the average dimensions. As far as possible, measurements were taken on mature ascospores, usually pigmented and septate, since they are generally much wider than young ones. According to our observations, paraphyses are easily damaged and often collapse in lactic acid, therefore they were studied in aqueous media, as a rule in Congo red aq. and phloxin.

Terminology

Some terms used either in the key or in the descriptions need to be clarified as they could have been used in a different sense by previous authors. In morphological description of ascospores, proximal means basal and distal means apical, in relation with the point of attachment of ascal stipe. The term seta (setae) is used in a general sense, including the terms hairs and bristles that differ only in a subjective way in the absence of precise discriminant characters. Both tomentum and subiculum are felt-like layers composed of loosely interwoven hyphae, but the former covers the perithecia while the latter covers the substratum and often spreads into it. Subapical globulus and apical ring are used according to the sense admitted by Lundqvist (1972). Other terms are used according to Ulloa & Hanlin (2000).

Key to lignicolous species of Lasiosphaeria

Perithecial setae, tomentum or subiculum are usually very distinctive but their presence may be variable, thus are considered as lower level characters in the key. Peridium anatomy is a valuable feature that is unfortunately not described in many cases. Ascospore shape is considered as being the most reliable character, therefore it is proposed as the entry point for the key. The ascospores are classified into four morphological types according to their shape (Fig. 1a-d).

- Ascospores bent more or less in the middle or almost straight.
  - Ascospores allantoid, oblong, bean or banana-shaped, ratio length / width < 7..**A**

  - Ascospores cylindrical or vermiform, ratio length / width > (8) 9....................................**B**

- Ascospores bent in the lower third or quarter, geniculate to sigmoid
  - Ascospores geniculate, the bent part tapering into a sharp point ....**C**

  - Ascospores geniculate or sigmoid, rounded at both ends or only at distal end and then proximal end conical to slightly tapering, sometimes with hyaline appendages......**D**

A- Perithecia small, glabrous, about 150 μm high, fringed around the base with short brown hyphae 35 – 60 x 3 μm. Ascospores fusoid oblong slightly curved, yellowish, obscurely 7 – 9-septate, 35 – 40 x 6 – 7 μm..................

……………………………………………………*L. trichopus* Ellis & Everh.
A – Perithecia higher than 250 µm……………………………………………**A1**

A1 – Perithecia glabrous ……………………………………………………**A2**
A1 – Perithecia setose………………………………………………………**A3**
A1 – Perithecia covered by a tomentum……………………………………**A8**

A2 – Perithecia smooth, usually densely gregarious. Ascospores allantoid, hyaline, nonseptate, 19 – 23 x 3 – 4 µm………………………………………… ……………………………………***L. spermoides*** (Hoffm.) Ces. & de Not.
A2 – Perithecia tuberculate, reminiscent of *Bertia moriformis*. Only known on coniferous wood. Ascospores allantoid, sooty-brown, up to 3 – septate, 28 – 31.5 x 6 – 7µm……………………………………… ***L. porifera*** Réblová.

A3 – Ascospores width less than 8 µm…………………………………**A4**
A3 – Ascospores width more than 8 µm…………………………………**A6**

A4 – Perithecia black, covered by dark brown conidiophores of an associated *Endophragmiella* and light brown thick-walled setae. Ostiolar neck conical and sulcate. Ascospores banana-shaped, rough, up to 5 – septate, 34 – 42 x 4 – 6.8 µm…………………………………………… ***L. punctata*** Munk
A4 – Perithecia dark brown, covered by thick-walled setae varying from red - brown to whitish. Ostiolar area obtuse, nonsulcate……………………………**A5**

A5 – Ascospores allantoid, smooth, 0 – 1- septate, 18 – 22 x 4 – 5 µm……… …………………………………***L. canescens***[2] (Alb. & Schwein. : Fr.) Sacc. **A5** – Ascospores banana-shaped with conical ends, wall smooth to verruculose, 1 – 3-septate, 30 – 38 x 5.5 – 7 µm………………………… ……………………………………………***L. strigosa***[2] (Pers. : Fr.) P. Karst.

A6 – Ascospores fusoid – oblong with rounded ends, almost straight, 7 – 15 – septate, 45 – 65 x 8 – 10 µm. Perithecia clothed with long stout setae 6 – 7µm wide, except the papilla………………………………*L. hystrix* Ellis & Everh.
A6 - Ascospores wide allantoid, shorter……………………………………… **A7**

A7– Perithecial wall light brown, apex light brown, almost glabrous, papillate. Ascospores allantoid, smooth to verruculose, yellowish to light brown, 1-3-septate, 25 – 30 x 8 – 12 µm…………………… ***L. pallida***[3] sp. nov.
A7 – Perithecial wall black, apex black and cruciform. Ascospores allantoid to bean- shaped, smooth to minutely verruculose, light yellow, 1- septate, 23 – 34 x 6.8 – 11 µm……………………………………***L. stuppea*** Ellis & Everh.

A8 – Perithecial contents pink. Perithecia 500 µm high, 400 µm in diam., covered by greyish-white sinuate hyphae. Ascospores cylindrical to allantoid,

smooth, pinkish, (28) 36 – 40 (45) x 6 – 7 (8) µm. Asci without subapical globulus... *L. sorbina* (Nyl.) P. Karst.
A8 – Perithecial contents hyaline to yellowish................................. **A9**

A9– Perithecia subglobose 460 – 540 µm high with a caplike apex, covered by a brown tomentum. Asci with a subapical globulus indistinct or 2 µm in diam. Ascospores oblong with rounded ends, verruculose, yellowish, 1 – 7 septate, 32 – 45 x 6.8 – 8.8 µm................................ ***L. capitata*** sp. nov.
A9 – Perithecia more conical, 160 – 360 µm high, with a pointed papilla, covered by a yellowish tomentum. Asci with an irregular subapical globulus 3 – 3.5 µm in diam. Ascospores oblong to clavate, slightly curved, smooth, yellowish, up to 7 - septate, 30 – 43.5 x 5.5 – 7.5 µm........ ***L. vestita*** sp. nov.

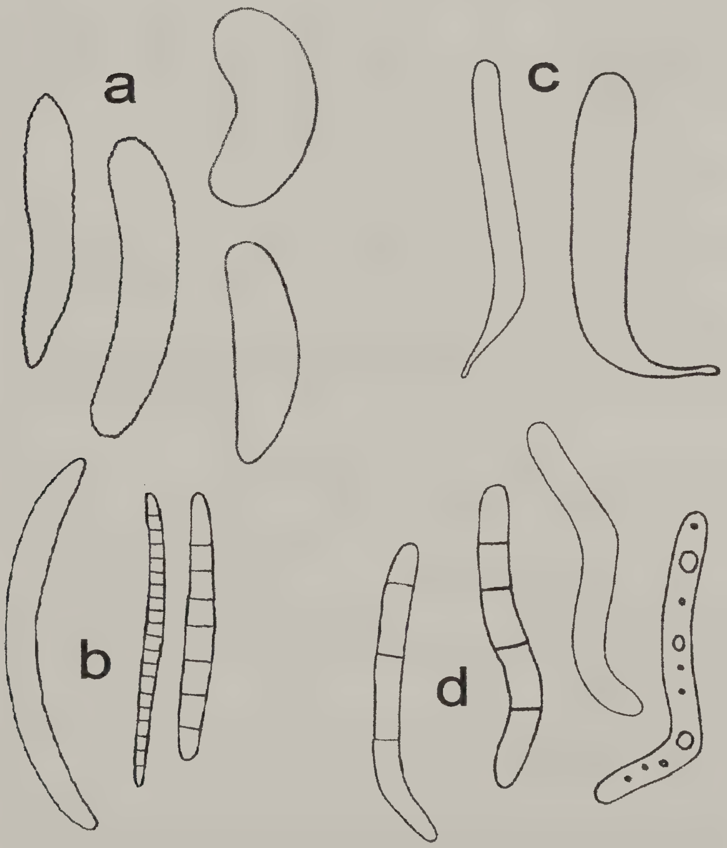

Figure 1: Ascospore shape as considered in the proposed key

B – Perithecia glabrous (the apical papilla may be of short setae less than 15 µm long). Subiculum, if present, hardly visible.......................... **B1**
B – Perithecia setose. Subiculum possibly well developed.................... **B6**

B1 – Ascospores aseptate, 46 – 56 x 6.6 – 7 (-8) µm..........................
....*L. cylindrospora* L. N. Vasilyeva
B1 – Ascospores multiseptate... **B2**

B2 – Ascospores longer than 70 µm.. **B3**
B2 – Ascospores shorter than 70 µm... **B4**

B3 – Ascospores 5 – 7 - septate, 80 x 6 µm.................. *L. depilata* Fuckel
B3 – Ascospores up to 8 – 12- septate, 90 – 115 x 5 – 5.5 µm.................
....*L. glabra* Rossman

B4 – Perithecia 430 – 530 µm in diam., peridium 70 – 90 µm thick with a dark brown median layer of brick-like almost opaque cells. Perithecial contents pink. Ascospores 7 – septate, 40 – 50 x 5 – 6 µm.......................
....*L. lapaziana* Carroll & Munk.
B4 – Perithecia smaller, not exceeding 250 µm in diam...................... **B5**

B5 – Peridium 12 – 16 µm thick, pseudoparenchymatous. Papilla of short dark brown setae up to 15 µm long. Ascospores 3 – 7 – septate, 50 – 70 x 3 – 4 µm.. *L. ellisii*[4] M. E. Barr
B5 – Peridium 20 – 35 µm thick, with an opaque carbonaceous inner layer. Ascospores 9- septate, 40 – 50 x 4 – 5 µm. Found associated with *L. spermoides*.. *L. mycophila* Carroll & Munk

B6 – Perithecia globose, 500 – 700 µm in diam.. Setae brown, up to 200 µm long, 12 – 14 µm wide at the base. Ascospores nonseptate with a proximal apiculus 7 – 8 µm long, 64 – 68 x 3.5 – 4 (-4.5) µm............................
....*L. angustispora*[5] L.N.Vasilyeva
B6 – Perithecia conical with a flattened base, 250 – 300 µm in diam. Setae black, up to 60 µm long, 4 – 5 µm wide at the base. Ascospores 13 – 17 – septate, 50 – 65 x 2 – 4 µm... ***L. raciborskii.*** (Penz. & Sacc.) Carroll & Munk

C – Ascospores shorter than 45 µm... **C1**
C – Ascospores longer than 45 µm.. **C3**

C1 – Ascospores not pigmented in asci, 1–septate. Perithecia partly immersed, often covered by reddish - brown aseptate setae. Ascospores hyaline to light brown, (18-) 23 – 32 x 3.5 – 4.5 (-5.5) µm....................
.... ***L. munkii*** R & O Hilber.

C1 – Ascospores already pigmented in asci, 3 – 6- septate……………… **C2**

C2 – Ascospore width more than 4.5 µm, 3- septate, at times with a rounded diverticle at the distal end, 28 – 33 x 4.5 – 6 µm………………….… ***L. sp.1***
C2 – Ascospore width less than 4.5 µm, becoming sooty - grey, 3 – 6 – septate, 40 – 46 x 3.2 – 4 µm………………………….. ***L. breviseta*** P. Karst.

C3 – Perithecia covered by reddish - brown stiff setae, rarely 1 – septate near the base. Ascospores hyaline to yellowish, 3 – septate, 48 – 58 x 3.5 – 3.8 µm……………………………………………………… ***L. rufa*** sp. nov.
C3 – Perithecia covered by long black shining septate setae. Ascospores longer. ………………………………………………………………..**C4**

C4 – Ascospores hyaline to light brown, 5 – 8 (10) – septate, (55) 62 – 90 x (4) 4.5 – 6 (7.2) µm………………………………… *L. meznaensis* R. Hilber
C4 – Ascospores hyaline to yellowish, 3-septate, 55 – 68 x 6 µm………….
……………………………………………………..……***L. caudata*** (Fuckel) Sacc.

D – Ascospores shorter than 30 µm. Perithecia small-sized, 250 – 400 µm in diam., seated in a brown subiculum. Ascospores sigmoid, hyaline, nonseptate, (19.6) 22 – 27 x 4.5 –5 (6) µm……... *L. insignis* L. N. Vasilyeva.
D – Ascospores longer than 30 µm…………………………………….. **D1**

D1 – Perithecial wall membranaceous, fragile. Perithecia immersed in wood at least in first stages……………………………………………………… **D2**
D1 – Perithecial wall leathery. Perithecia superficial……………………...**D4**

D2 – Ascospores olive - brown to brown, geniculate, 1 – 3 (4) – septate, 28.5 – 36.8 x 5.5 – 7.5 µm. ……………………………….***L. volvestriana*** sp. nov.
D2 – Ascospores hyaline, sigmoid turning geniculate……………………..**D3**

D3 – Ascospores nonseptate, 50 – 60 x 5 – 6 µm. Perithecial contents chrome – yellow. Perithecia becoming superficial…………… *L. glabrata* (Fr.) Munk
D3 – Ascospores up to 7-septate, (38) – 43 – 51 x (3.5)- 4.2 - 4.6(5.7)µm. Perithecial contents hyaline to yellowish. Perithecia remaining immersed…………………………………………….***L. immersa*** P. Karst.

D4 – Peridium with an outer layer of textura prismatica to epidermoidea. Perithecia covered by a whitish tomentum………………………..……… **D5**
D4 – Peridium pseudoparenchymatous. If present, tomentum dark brown..**D6**

D5 – Ascospores smooth, hyaline to yellowish, appendaged when young, 42 – 46 x 5 µm, subapical globulus warted, hyaline, 3 µm in diam……………...

…………………………………………***L. ovina*** (Pers. : Fr.) Ces. & de Not.

D5 – Ascospores pitted, yellowish, appendaged when young, 42 – 46 x 5 µm, subapical globulus echinulate, golden – brown, 4 – 5 µm in diam……………………………………………………*L. chrysentera* Carroll & Munk

D6 – Ascospores already pigmented in asci, geniculate, proximal end attenuated, 3 – 4 –septate, 42 – 55 x 4 – 4.6 µm. Perithecia roughly tuberculate, with a conical sulcate ostiolar neck, covered by robust brown setae…………………………………………………… ***L. moseri*** O. Hilber

D6 – Ascospores hyaline in asci, possibly becoming yellowish to light brown at maturity…………………………………………………………… **D7**

D7 – Ascospores sigmoid, hyaline, with acute fugacious appendages when young, becoming geniculate, light brown and up to 7(8)-septate when mature, 50 – 72 x 5 – 7 µm. Perithecia almost glabrous to densely setose, tuberculate ……………………………………………***L. hirsuta***[6] (Fr.) Ces. & de Not.
L. hispida (Tode : Fr.) Fuckel
L. tuberculosa Carroll & Munk
L. rhacodium (Pers. : Fr.) Ces. & de Not.

D7– Ascospores remaining hyaline at maturity, shorter…………………**D8**

D8 – Perithecia covered by a dark brown tomentum. Ostiolar neck well differentiated, black, coarsely pitted. Ascospores sigmoid, nonappendaged, 1 – 3-septate, (43) 46 – 53 (58) x 3.5 – 5 µm…………………………… ***L. sp. 2***

D8 – Perithecia glabrous, upper portion conical becoming sulcate when dry. Ascospores sigmoid, distal end slightly capitate, proximal end with a blunt gelatinous appendage, up to 12 – septate, 42 – 55 x 3.5 – 5 µm………………………………………………………………***L. pyramidata*** Carroll & Munk

Notes.

[2] Following Hilber & Hilber (1978), we temporarily keep the usual distinction between *L. strigosa* and *L. canescens*, mainly based on ascospore morphology and dimensions, although all intermediate forms may be encountered (Candoussau et al., in prep.).

[3] A *Lasiosphaeria* sp. collected in Norway by Prof. Lundqvist (SOGN OG FJORDANE: Sogndal commune, on deciduous wood, 08 Sept. 2000, N. Lundqvist 21312) is highly similar to *L. pallida* but differs in much smaller ascospores 16 – 17.5 x 4 – 5.5 µm. This fungus is probably to be considered as a small – spored variety of *L. pallida,* but additional material is needed from different regions for assessing the range of natural variations of ascospores in this species.

[4] *Sphaeria longispora* Ellis is reported by M. Barr (1993) as having longer ascospores (80 – 100 x 3 – 4 µm) and as being a possible variety of *L. ellisii.*

[5] *Lasiosphaeria angustispora* is placed in this section of the key according to the description of Vasilyeva (1998) who described its ascospores as being long cylindrical, without any reference to curvation in the proximal end, although she points out that they resemble those of *L. breviseta* and *L. meznaensis*, maybe on account of the proximal apiculus. Until this species comes to be illustrated, its ascospores are considered as being straight.

[6] These four species, *L. hirsuta, L. hispida, L. rhacodium* and *L. tuberculosa* are considered as a complex with similar asci, ascospores and peridial anatomy, only differing in the density of subiculum and setae and in perithecial apex shape, in which all intermediate forms may be encountered, even within the same collection. However, *L. hispida* is usually distinguished from *L. hirsuta* by its conical nonsulcate papilla and by its setae arising separately, not in fascicules on tubercles. *Lasiosphaeria rhacodium* may be considered different from *L. hirsuta* in having very dark brown to nearly black perithecia and an abundantly developed subiculum that covers the surrounding substratum, giving to the irregularly crowded groups of perithecia a black crust-like appearance.

The names of the species we have had the opportunity to examine are written in boldface types.

For a description of the species listed in the key that are not treated in this paper, we suggest the following references:
L. angustispora in Vasilyeva (1998), *L. breviseta* in Hilber & Hilber (1983), *L. canescens* in Hilber & Hilber (1978), *L. caudata* in Munk (1957), *L. chrysentera* in Carroll & Munk (1964), *L. cylindrospora* in Vasilyeva (1998), *L. depilata* in Fuckel (1870) and Rossman (1977), *L. ellisii* in Barr (1993), *L. glabra* in Rossman (1977), *L. glabrata* in Munk (1957), *L. hispida* in Munk (1957), *L. hirsuta* in Dennis (1978), *L. hystrix* in Ellis & Everhart (1894), *L. immersa* in Hilber & Hilber (1983), *L. insignis* in Vasilyeva (1998), *L. lapaziana* in Carroll & Munk (1964), *L. meznaensis* in Hilber & Hilber (1983), *L. moseri* in Hilber & Hilber (1983), *L. munkii* in Hilber et al. (1987), *L. mycophila* in Carroll & Munk (1964), *L. ovina* in Munk (1957), *L. porifera* in Réblová (1998), *L. raciborskii* in Carroll & Munk (1964), *L. rhacodium* in Ellis & Everhart (1892), *L. sorbina* in Munk (1957), *L. spermoides* in Munk (1957), *L. strigosa* in Hilber & Hilber (1978), *L. trichopus* in Ellis & Everhart (1893), *L. tuberculosa* in Carroll & Munk (1964).

Descriptions

1 - ***Lasiosphaeria capitata*** F. Candoussau, J. Fournier & J.F. Magni, sp. nov., Figs. 2, 10-*a*, 11-*a*, 12-*a*.

Perithecia dispersa vel confertim gregaria, superficialia, subglobosa vel obpyriformia, 340-480 µm lata, 460-540 µm alta, atrobrunnea, tomentosa, tomento 25-30 µm crasso, textura intricata ex hyphis brunneis 2.5-3 µm latis composita, apice late rotundato, capitato, atrobrunneo, convexo ad applanato, non papillato. Peridium 50-70 µm latum, coriaceum, duobus stratis compositum. Paraphyses numerosae, filiformes, 2-3 µm latae. Asci octospori, 150-190 x 20-31 µm, pars sporifera 108-156 µm, stipes 33-46 µm, cylindracei vel clavati. Annulus apicalis refractivus, indistinctus, 2 µm latus. Globulus subapicalis levis, 2-2.5 µm diametro. Ascosporae 32-45 x 6.8-8.8 µm (40.5 x 7.5 µm media dimensione), oblongae, leviter curvatae, extremitatibus rotundatis, hyalinae, laeves, neque septatae dum juvenes, aetate provecta verrucosae, pallide flavae 1-3(7)-septataeque, biseriatae vel multiseriatae. Holotypus: Gallia, in regione dicta "Ariège, Rimont, Las Muros". In cortice *Fraxini excelsioris*, 25 Jan. 1999, leg. J. Fournier, JF-9910, CUP-65601.

Perithecia scattered to densely gregarious, superficial to slightly sunken in the substratum, subglobose to obpyriform with a flattened base, dark brown to blackish brown, 340 – 480 µm in diam., 460 – 540 µm high, covered with a felty brown tomentum except at the apex. Tomentum 25 – 30 µm thick, *textura intricata,* of brown, thick-walled, flexuous, smooth, septate, ramified, 2.5 – 3 µm wide hyphae with obtuse often slightly inflated tips. Apex covered with thick-walled, radially arranged brown cells, 6.5 – 8 x 3 – 5 µm, with rounded tips. Tomentum continuing into the subiculum around on the substratum or connected with the tomentum of other perithecia when they are in contact. Perithecial apex widely rounded, caplike, dark brown, 160 – 200 µm in diam., 150 µm high, flattened at the top or slightly convex, nonpapillate, provided with a porus 15 – 20 µm wide. **Peridium** coriaceous, 50 – 70 µm thick, dark brown, two-layered. *Outer layer* 20 – 30 µm thick, apparently amorphous, *textura epidermoidea*, composed of hyaline to yellowish hyphae 1.5 µm wide, densely interwoven. This layer disappears at the base, as does the tomentum. *Inner layer* 25 – 40 µm thick, *textura angularis* of moderately thick-walled cells 8 – 13 x 5 – 6.5 µm, to *textura prismatica* of cells 10 – 12 x 3 – 4 µm, more thin-walled and more flattened toward the inside. The apical zone composed of a thickening of the outer layer up to 80 µm through which numerous dark brown radiating hyphae emerge from the inner layer. Ostiolar canal densely periphysate. Perithecial contents yellowish, gelatinous, not easily removed from the perithecial wall. **Asci** 8 – spored, unitunicate, 150 – 190 x 20 – 31 µm, the spore-bearing parts 108 – 156 µm, the stipes 33 – 46 µm, cylindrical-clavate, rounded at the apex. Apical ring indistinct, refractive, inamyloid, 2 µm wide, a subapical

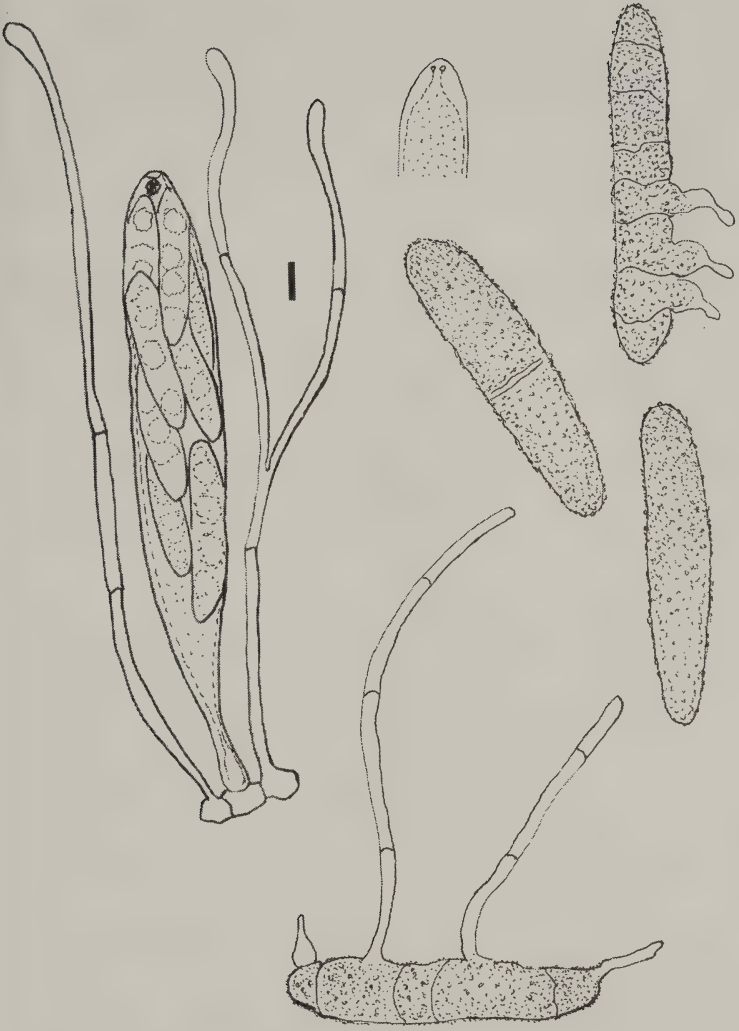

Figure 2: *L. capitata* (holotypus, CUP-65601). Ascus, paraphyses and ascospores (two germinating ascospores). Bars = 10 µm.

globulus only visible in young asci, 2 – 2.5 µm in diam., globose, smooth, refractive. The subapical chamber is usually tapering to the apical ring, giving to the ascal wall the appearance of a thickening. **Paraphyses** numerous, filiform, 2 – 3 µm wide, scarcely branched, inflated in places up to 5 µm. **Ascospores** 32 – 45 x 6.8 – 8.8 µm (mean value = 40.5 x 7.5 µm), oblong, slightly curved in the middle with rounded ends, hyaline, smooth or minutely punctate, multiguttulate, aseptate when immature, at maturity verruculose, pale yellowish, 1–3 (-7)- septate, biseriate to irregularly clustered in the upper part of the asci. Germination by phialides or germ tubes observed on very mature ascospores.

Associated anamorph unknown.

Habitat: Saprobic on dead branches of deciduous trees still joined to the tree, associated with old stromata of *Hypoxylon* sp. on bark of *Fraxinus,* and on *Quercus* branch on the decorticated area previously occupied by a *Vuilleminia* sp.

Etymology: from latin *caput* (= head), referring to the widely rounded perithecial apex.

Specimens examined: FRANCE. Ariège (09). Rimont, Las Muros, on freshly fallen down dead branch of *Fraxinus excelsior*, 25 Jan. 1999, JF-9910 (HOLOTYPE, CUP – 65601, ISOTYPE S F14586); On decorticated branch of *Quercus robur*, 14 Dec. 1999, JF – 99287.

Discussion. *Lasiosphaeria capitata* shows affinity with L. *ovina,* the type species of the genus, in similar perithecial anatomy : presence of tomentum and inner layer of prismatic cells, gelatinous perithecial contents not easily removed from the wall and subapical globulus. It differs from *L. ovina* and from the closely related *L. chrysentera* in having a caplike perithecial apex, a brown tomentum, an indistinct apical ring and suballantoid to oblong ascospores, while the former possess acute papillate perithecial apex, white tomentum, conspicuous apical ring and longer, narrower, cylindrical ascospores bent in the lower third, smooth in *L. ovina* and pitted in *L. chrysentera.*

Lasiosphaeria vestita is related to *L. capitata* in having similar peridial anatomy and ascospore shape but differs in having smaller perithecia, a white or yellowish tomentum and a conical perithecial apex.

Similar oblong ascospores are reported in *L. trichopus* and *L. sorbina.* The former differs from *L. capitata* in having much smaller glabrous perithecia, fringed around the base with short brown hyphae, the latter in having a greyish covering and pink perithecial contents.

The occurrence of *L. capitata* on dead branches still joined to the trunk of deciduous trees is likely to indicate ecological requirements strikingly different from what is observed for the other members of the genus, which require a high level of moisture for their development, and which are usually found on rotten wood lying on the ground.

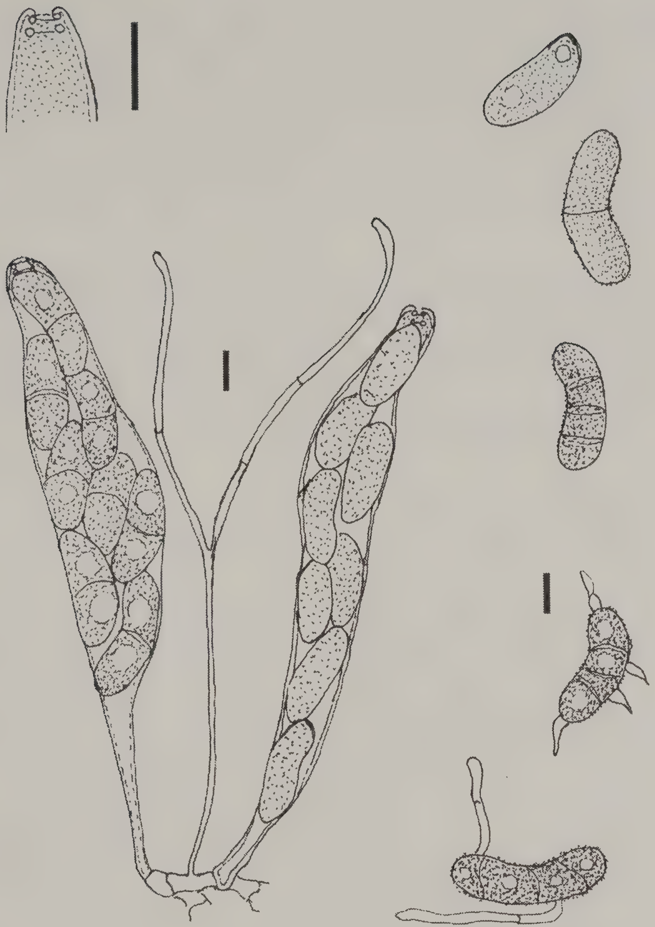

Figure 3: *L. pallida* (holotype CUP_65602). Ascus, paraphyses and acospores (two germinating ascospores). Bars = 10 µm.

2- ***Lasiosphaeria pallida*** F. Candoussau, J. Fournier & J.F. Magni, sp. nov., Figs. 3, 10-*b*, 11-*b*, 12-*b*, 13-*a,f*.

Perithecia dispersa vel gregaria, superficialia, obpyriformia, 400-550 µm lata, 550-750 µm alta, pallide ochracea, dense setosa. Setae flavae, cylindraceae, rectae vel flexuosae, apice obtuso vel rarius acutato, crassitunicatae, ad 200 µm longae et 8-15 µm latae. Apice perithecii ostiolato, conico vel cylindraceo, fere glabro, pallide brunneo, 70-80 µm lato, 100-120 µm alto. Subiculum praesens, flavidulum, laxum vel inconspicuum. Peridium 55-65 µm latum, molle, coriaceum, duobus stratis compositum. Periphyses copiosae. Paraphyses numerosae, filiformes, ramosae, sparsim septatae, hyalinae, 1-2 µm latae. Pars interior perithecii albida. Asci octospori, 124 –142 x18-21µm, pars sporifera 96-112µm, stipes 16-36µm, cylindracei vel clavati, apice truncato. Annulus apicalis distinctus, bistratosus, refractivus, inamyloideus, 5.5 x 1.5 µm. Globulus subapicalis abest. Ascosporae 25.2-30 x 8.2-12.2 µm (28.5 x 9.3 µm media dimensione), late allantoideae, laeviter vel valde curvatae in medio, extremitatibus rotundatis, flavidae vel pallide brunneae, laeves vel verruculosae, 1-3-septatae, biseriatae vel triseriatae. Phialides vel hyphae germinativae ex ascosporis orientes. Holotypus: Gallia, in regione dicta "Pyrénées Atlantiques, Forêt Domaniale d'Oloron". In ligno *Acer negundo*, 24 Aug. 1997, leg. F. Candoussau, FC-5094-511, CUP-65602

Perithecia scattered or in small groups, superficial, obpyriforme, light ochraceous, 400-550 µm in diam., 550-670 µm high, densely setose. Setae yellowish, cylindrical, straight or flexuous, denticulate in places, with a blunt or rarely pointed apex, very thick- walled, lumen often absent, at times 1-septate near the base, up to 200 µm long, 8-15 µm wide. Apex ostiolate, papillate, conical to cylindrical, almost glabrous, light brown, 60-80 µm in diam.,100-120 µm high. Subiculum present, loose to inconspicuous, yellowish, hyphae 8 µm wide thin to thick-walled. **Peridium** soft, 55-65 µm thick, yellowish to light brown, two-layered. *Outer layer* 25-30 µm thick, *textura angularis* of thick-walled cells, 10-16 µm in diam., wall 3-5 µm thick, light brown. *Inner layer* 30-35 µm thick, *textura prismatica* composed of 6-10 rows of hyaline thin-walled cells, 15-30 x 7-8 µm. *Apex* composed of parallel hyphal elements, yellowish, cylindrical with a slightly enlarged rounded tip, 1.5-2 µm wide, emerging from the inner layer. Ostiolar canal densely periphysate. **Asci** 8-spored, unitunicate, cylindrical to clavate, truncate at the apex, 124-142 x 18-21 µm, spore bearing-parts 96-112 µm, stipes 16-36 µm. Apical ring present, double, refractive, inamyloid, 5.5 x 1.5 µm, subapical globulus absent. **Paraphyses** filiform, numerous, longer than the asci, ramified, sparsely septate, hyaline, 1-2 µm wide. Perithecial contents whitish. **Ascospores** 25.2-30 x 8.2-12.2 µm (mean values: 28.4 x 9.3 µm), wide allantoid, slightly to strongly curved in the middle, with rounded ends, yellowish to light brown, smooth or verruculose, 1-3-septate, 2-3-seriate in the upper part of the asci. Germination either by phialiades or by germ tubes. **Associated anamorph**: unknown.

Habitat: Saprobic on deciduous wood lying on the ground. **Etymology:** from latin *pallidus* (= pale), referring to the light brown perithecial color.

Specimens examined. FRANCE. `Pyrénées Atlantiques (64)`. Oloron, Forêt domaniale d'Oloron, on *Acer negundo*, 24 Aug. 1997, `FC-5094-511,(HOLOTYPE CUP-65602, ISOTYPE S F14584)`. Oloron, Forêt de Bugangue, on deciduous wood on the ground, 18 Oct. 1997, `FC-5094-512`. Oloron, Forêt domaniale d'Oloron, on *Acer negundo*, 31 Aug. 1997, `FC-5094-513`. Barthes de l'Hôpital St. Blaise, vic. Mauleon, on *Alnus*, 21 March 1998, `FC-5094-583`.

Discussion. *Lasiosphaeria pallida* is characterized by soft, light pigmented perithecia bearing dense flexuous thick-walled setae and having glabrous conical ostiolar necks, ascal apices provided with a double apical ring and by wide allantoid pigmented ascospores. It should be compared with two other species having similarly shaped ascospores, *L. porifera* and *L. stuppea*, which both differ from *L. pallida* in perithecial morphology and peridial anatomy. *L. porifera* has black, tuberculate, weakly papillate glabrous perithecia and areolate peridium, while *L. stuppea* has black, sparsely setose perithecia with a strongly tuberculate apex, and thick, two-layered and strongly melanized peridium. Other *Lasiosphaeria* species provided with dense thick-walled setae, *L. canescens, L. strigosa* and *L. rufa* differ in having acute, stiff and differently colored setae, reddish-brown turning whitish in *L. canescens* and *L. strigosa*, rust in *L. rufa*. Moreover, they differ from *L. pallida* in having differently shaped ascospores, narrowly allantoid in *L. canescens*, slightly allantoid with conical ends in *L. strigosa* and cylindrical geniculate with a spiny acute tip in *L. rufa*.

3 - *Lasiosphaeria punctata* Munk, Dansk. Bot. Arkiv 17: 114, 1957. Figs. 4, 10-*c*, 11-*c*, 12-*c*, 13-*b,g*.

Perithecia densely gregarious, superficial, growing among a dark brown subiculum of the associated anamorph, ovoid, not collapsing when dry, black, 410-520 µm in diam., 400-650 µm high, slightly roughened to distinctly tuberculate, tubercles up to 70 µm in diam., when young densely covered with setae and dark conidiophores, later becoming almost glabrous. Setae straight or curved, acute, very thick-walled, light brown, 110-270 x 15(20) µm at the base, lumen 1-2 µm wide. Dark conidiophores cylindrical with a tapering apex, multiseptate, wall up to 2 µm thick, 90-280 µm long, 5-8 µm wide at the base. Apex ostiolate, conical, slightly to deeply 3-6-sulcate, black, 130-160 µm in diam. at the base, 120-180 µm high, ostiolar canal opening by a pore. **Peridium** tough, coriaceous, 30-65 µm thick, blackish brown, two-layered. *Outer layer* 25-58 µm thick, *textura angularis* of 7-12 rows of thick-walled cells 6.5-10 x 5-6.5 µm, wall dark brown 1.5 µm thick, becoming gradually more opaque and pigmented toward the periphery and more elongate and flattened toward the interior, up to 17 x 3.5 µm. *Inner layer* 7-l0 µm thick, *textura prismatica* of hyaline to light brown cells. Ostiolar neck a palisadic structure of tightly aggregated thick-walled elongated cells, 14-20 x 3.5-5 µm, dark brown, with rounded tips, emerging from the deepest part of the outer layer, perpendicularly to the ascomal surface. **Asci** 8-spored, unitunicate, broadly fusiform truncate at the apex, 124-147 µm in total length, spore-bearing parts 100-120 x 14-19 µm, stipes 23-37 µm. Apical ring present, refractive, inamyloid, 3 x 0.75 µm, subapical globulus absent.

Paraphyses copious, filiform, branched, 1.5-2.5 µm in diam.. Perithecial contents whitish, slimy. **Ascospores** 34-42 x 4.2-6.8 µm (mean values: 36.6 x 5.6 µm), banana-shaped, slightly curved in the middle with narrowly rounded to conical ends, yellowish, rough-walled, 1-3(-5)- septate, slightly constricted at the septa, often unequally two celled, the longer cell may be either the proximal or the distal one, the distal cell usually broader and more rounded at the end, the proximal cell narrower and more tapering, 2-3-seriate in the asci. Germination not observed. **Synanamorphs**: *Endophragmiella biseptata* (Peck) S. Hughes and *Selenosporella sp.*. *Endophragmiella biseptata*: conidiophores 6.5-8 µm in diam., brown, septate, up to 300 µm long, conidia pyriforme, two septate, 23-25 (29) x 13-15 µm, the proximal cell light brown, the two distal cells dark brown. *Selenosporella sp.*: not easily observed, apparently matching Hughes' description (1979).

Habitat: Saprobic on rotten deciduous or coniferous wood.

Specimens examined. FRANCE. `Pyrénées Atlantiques (64)`. L'Ourtau, Forêt du Bager d'Oloron, on *Fagus*, 27 Oct. 1996, `FC-5097-461`. Oloron, Forêt domaniale d'Oloron, on deciduous wood, 14 Sept. 1997, `FC-5097-532`. Oloron, Bois du Bager Sud, L'Ourtau, on coniferous wood, 2 Nov. 1997, `FC-5097-545`. Oloron, Forêt d'Oloron, on *Trametes sp.* on *Fagus*, 09 Nov. 1997, `JFM-9768`. `Ariège (09)`. Rimont, Las Muros, Ruisseau de Peyrau, on *Acer campestre*, 23 Sept. 1997, `JF-97154`. Rimont, Las Muros, on *Ulmus*, 12 Jan. 1998, `JF-9802`. Rimont, Las Muros, on decorticated wood of *Corylus avellana*, 15 Sept. 1998, `JF-98122`. Rimont, Las Muros, Ruisseau de Peyrau, on decorticated wood of *Ulmus minor*, 07 Dec. 1999, `JF-99278`. `Gironde (33)`. Mongauzy, on deciduous wood, 29 Nov. 1998, `JFM-9869`.

Discussion. *Lasiosphaeria punctata* was described by Munk (1957) and considered as being a *Lasiosphaeria* on account of its peridial anatomy, ascal morphology and ascospores shape. Hughes (1979) proposed *L. punctata* as the possible teleomorph of *Endophragmiella biseptata* associated with a *Selenosporella sp.* and *L. canescens* as the possible teleomorph of a *Selenosporella sp.* Sivanesan (1983), emphasizing the presence of the *Endophragmiella* anamorph and following the observations of Hughes, considered these members of the genus *Lasiosphaeria* as being closely related to the new genus *Phaeotrichosphaeria* that he created to accommodate unitunicate setose pyrenomycetes associated with an *Endophragmiella* and with 0-1-septate ovoid ascospores.

Lasiosphaeria punctata should be compared with *L. strigosa* which is the only member of the *Lasiosphaeria* that at the same time may be associated with an *Endophragmiella* and has somewhat banana-shaped, 1-3-septate, yellowish ascospores. *L. strigosa* differs markedly in having dense thick-

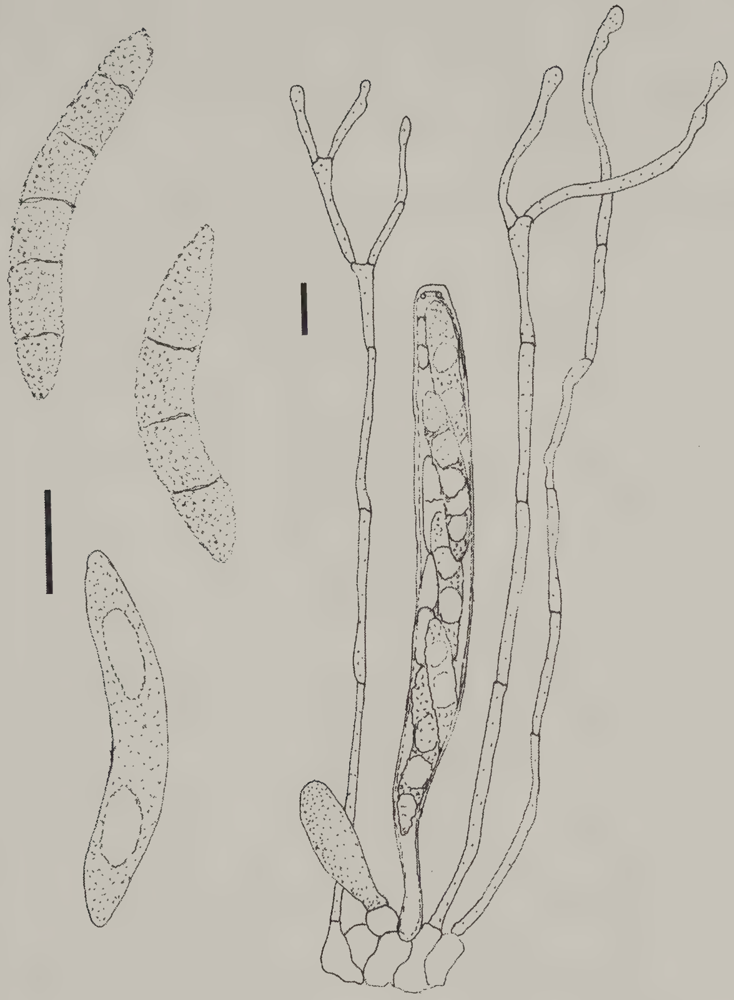

Figure 4: *L. punctata* Ascus, paraphyses and ascospores. Bars =10 µm. From FC-5096-461

walled pointed setae, ranging from red brown to yellowish grey, in having a smooth obtuse ostiolar area, and in ornamentation of ascospores wall which is minutely verruculose. In addition, *L. rufa* has also been found associated with an *Endophragmiella* but it differs mainly from *L. punctata* in its rust colored pointed setae and geniculate ascospores abruptly ending in an acute tip. Moreover, it should be noted that in the case of *L. strigosa* and *L. rufa*, according to our observations, the *Endophragmiella* has always been found growing with old, empty and decaying perithecia, but never associated with young perithecia, as it is always observed in the case of *L. punctata*. The synanamorphs always associated with *L. punctata* are very distinctive features among other *Lasiosphaeria*, but more is still to be known about the anamorphs in this genus before appreciating their taxonomic value.

4 - *Lasiosphaeria pyramidata* Carroll & Munk, Mycologia, 56: 84, 1964, Figs. 5, 10-*d*, 11-*d*, 12-*d*, 13-*h*.

Perithecia as a rule densely crowded and half immersed in the wood but sometimes scattered or almost superficial, 380-450 µm in diam., 500 - 600 µm high, the upper portion conical, 4-6-sulcate when dry, rough, black, the base rounded and more or less immersed. Apex opening by a pore but not differentiated. Subiculum present, usually conspicuous, sometimes completely absent, dark brown, covering the wood between the perithecia but not the conical portion of the perithecia, of hyphae 2-2.5 µm wide, partly inflated up to 5 µm, septate, brown, wall 0.5 µ. **Peridium** tough, leathery, blackish, 45-65 µm thick, two-layered. *Outer layer* 20-45 µm thick, consisting of black polygonal plates. Hyphae of plates are oriented radially and contain an opaque black substance. The observed *textura* depends on the location of the section with respect to the cut scales. *Textura angularis* is dominant, consisting of brown cells ranging from 5 to 10 µm. At the junction of scales, the structure of the outer layer appears to be in continuity with the inner one. *Inner layer* 15-20 µm thick, *textura prismatica* consisting of 5-7 rows of thin-walled brown cells, 5-15 µm long, up to 3 µm in diam. next to outer layer, smaller inside. In the *apical area*, the thickness of peridium layers reduced progressively towards the apex. Porus densely periphysate. **Asci** eight spored, unitunicate, ventricose, 140-162 x 12-13.5 µm, short stipitate, spore -bearing parts 115-120 µm long. Apical ring about 2 µm in diam. and less than 0.5 µm high. A refractive subapical globulus usually absent in our collections, when present about 2 µm in diam. **Paraphyses** fragile, very thin-walled, septate, 3-6 µm wide (they need to be observed on fresh material and in aqueous medium, otherwise they vanish). In herbarium material, some nondissolved paraphyses might be seen at the vicinity of the perithecial wall. Perithecial contents hyaline. **Ascospores** 42-55 x 3.5-5 µm cylindrical geniculate to slightly sigmoid, smooth, hyaline, provided at the proximal end with a blunt hyaline cellular appendage 3-6 µm long, the distal end rounded and often subcapitate, nonseptate when young, up to 12-septate when mature, biseriate to irregularly clustered in the asci, germination by germ tubes.

Associated anamorph unknown.

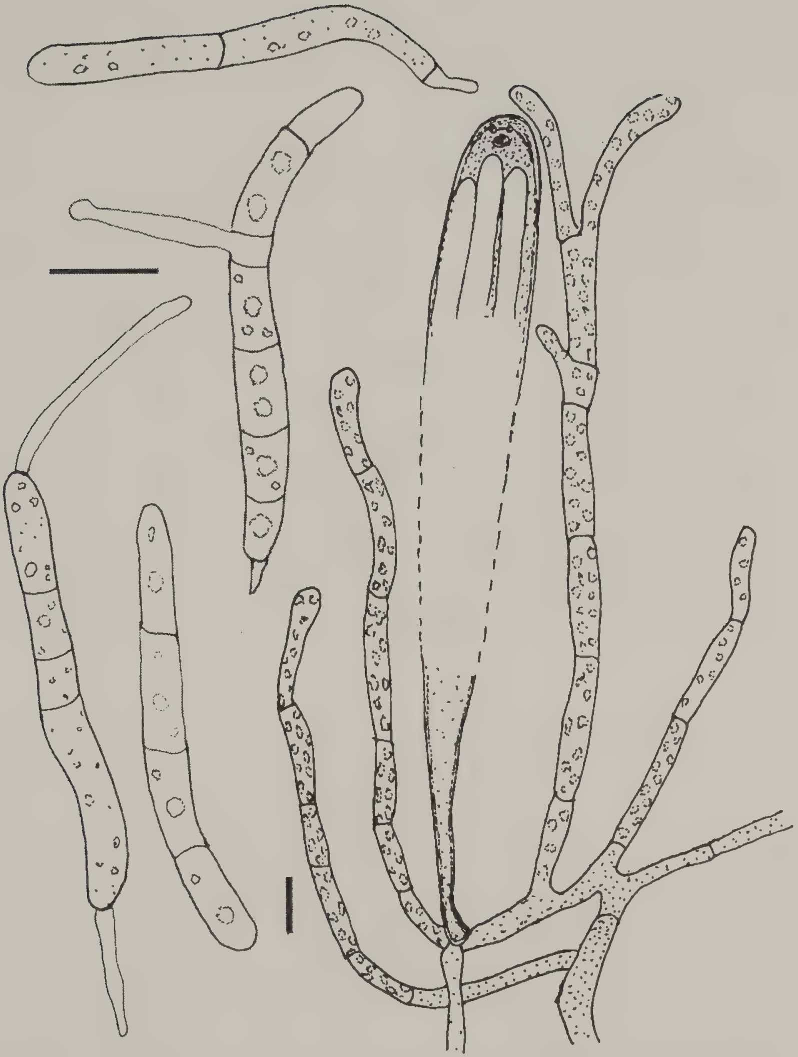

Figure 5: *L. pyramidata* Ascus, paraphyses and ascospores (two germinating ascospores). Bars = 10 µm. From JFM-0001

Habitat: On rotten deciduous wood.

Specimens examined. FRANCE Ariège (09) Rimont, Las Muros, on *Fraxinus excelsior*, 24 Oct. 1997, JF-97201. Rimont, Las Muros, on *Populus tremula*, 17 Dec. 1997, JF-97226. Rimont, Las Muros, on *Populus tremula*, 05 Dec. 1998, JF-98205. Rimont, Las Muros, on *Populus tremula*, 17 Mar. 1999, JF-9943.

`Pyrénées Atlantiques (64).` Auterrive, Gave d'Oloron bank, 24 Oct. 1999, `FC-5107-678.` Auterrive, Gave d'Oloron bank, 25 Dec. 1999, `FC-5107-686.` `Haute Garonne (31).` Clermont Lefort, Ramiers de l'Ariège, on *Populus*, 27 Feb. 2000, `JFM-0001(CUP-64955).`

Discussion. The original description of *Lasiosphaeria pyramidata* (Carroll & Munk, 1964) was based on a single collection. Our collections match well the type, as stated by Lundqvist (in lit., FC 19/03/2000). However, the present description is based on material from France, emphasizing details like variable development of subiculum, variable presence of subapical globulus, often subcapitate distal end of ascospores, their septation up to 12 and their germination by germ tubes. *Lasiosphaeria pyramidata* should be compared with other species of *Lasiosphaeria* having similar hyaline sigmoid ascospores, *L. glabrata, L. hirsuta, L. immersa, L. insignis, L. ovina* and *L. sp. 2.* It differs markedly from these species in having an areolate peridium and conical sulcate perithecia. The areolate structure of the peridium, easily observed in crushed mounts in 3% KOH, is a distinctive feature also encountered in *L. porifera*. A thorough discussion concerning the presence of this character in different species and genera is given in Réblová (1998). The outer appearence of *L. sp 2* (col. JFM-9917) is reminiscent of *L. pyramidata* but the peridium structure is not areolate and ostiolar necks are differentiated and pitted.

5 - ***Lasiosphaeria rufa*** F. Candoussau, J. Fournier & J.F. Magni, sp. nov., Figs. 6, 10-*e*, 11-*e*, 12-*e*, 13-d,*i*.

Perithecia dispersa vel confertim gregaria, superficialia, globosa vel ovoidea, ferrugineo-brunnea, 380-480 µm lata, 480-550 µm alta, dense setosa. Setae rufo-brunneae, rigidae, rectae vel contortae, apice obtuso vel saepius acutato, crassitunicatae, 35-130(200) x 9-15(25) µm. Apice perithecii ostiolato, ferrugineo-brunneo, non papillato. Subiculum abest. Peridium 50-65 µm latum, crassum, coriaceum, ferrugineo-brunneum, duobus stratis compositum. Periphyses non visae. Pars interior perithecii albida, gelatinosa. Paraphyses gelatinosae, 1.5-2 µm latae. Asci octospori, 115 – 128 x 6.5 - 15µm, pars sporifera 102 - 108µm, stipes 14 - 24µm, cylindracei vel fusiformes, apice rotundato. Annulus apicalis distinctus, inamyloideus, 2.5-3 µm latus. Globulus subapicalis abest. Ascosporae 48 -58 x 3.5-3.8 µm (51.8 x 3.5 µm media dimensione), cylindraceae, parum sigmoideae ad rectae, geniculatae ad basim, apice spinoso extremitate parum inflata terminantes, hyalinae vel flavidae, laeves, 1-3septatae, biseriatae ad 4-seriatae. Holotypus: Gallia, in regione dicta "Pyrénées Atlantiques, Oloron, Forêt de Bugangue". In ligno putrido, 5 Oct. 1997, leg. F. Candoussau, FC-5096-541, CUP-65603.

Perithecia gregarious to densely crowded, superficial to slightly immersed in the substratum, globose to ovoid, rust brown, 380-480 µm in diam., 480-550 µm high, densely setose, setae light reddish-brown, stiff, straight or contorted, blunt or more often with acute apex, thick-walled with a lumen 1.5-6 (8) µm wide, rarely septate near the base, 35-130 (200) x 9-15(25) µm.

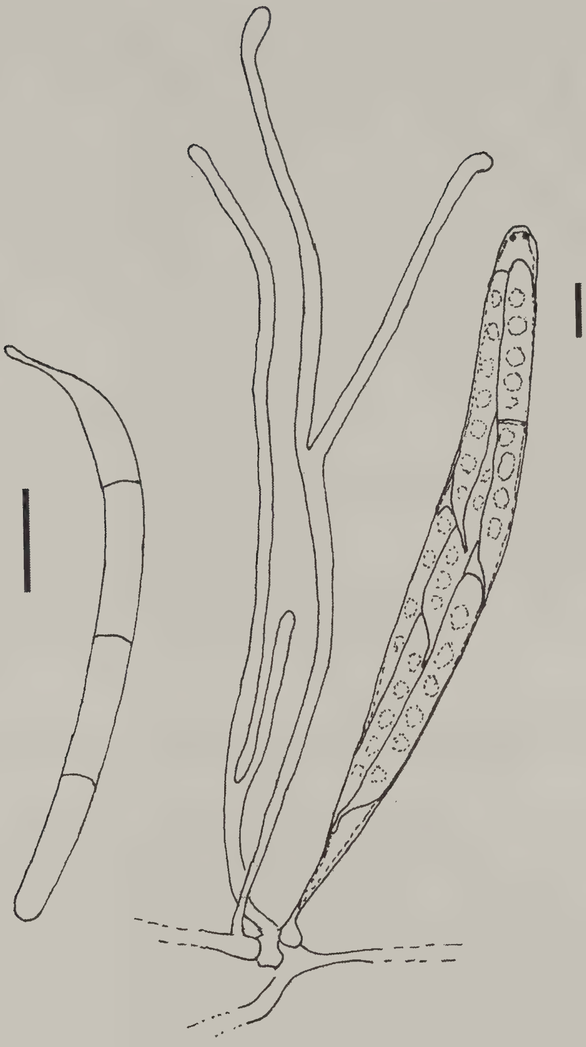

Figure 6: *L. rufa* (Holotype CUP-65603). Ascus, paraphyses and ascospores. Bars = 10 µm.

Apex nonpapillate, rust brown, glabrous, undifferentiated. Subiculum absent but some brown septate hyphae 5-6 µm wide, radiate into the substratum from the basal part of the perithecial wall. **Peridium** tough, leathery, 50-65 µm thick, rust brown, two-layered. *Outer layer* 16-25 µm thick, *textura angularis* of 1-2 rows of very thick - walled cells 13-28 µm in diam., wall rust brown, 3-6 µm thick. *Inner layer* 30-40µm thick, a transition between a *textura angularis* on the outer part with 3-6 rows of moderately thick-walled colored cells 16-25 x 8-10 µm, wall 1.5-2 µm thick, and a *textura prismatica* toward the center with light colored thin-walled cells 15-28 x 3-5 µm. Ostiolar area a thickening of the inner layer up to 60 µm with colored elongated cells 12-15 x 5 µm arranged vertically and basally lined by 6-10 rows of flattened hyaline cells 5-6 x 2.5-3 µm. Periphyses not observed. **Asci** 8-spored, unitunicate, cylindrical to fusiform rounded at the apex, 115-128 x 6.5-15 µm, spore-bearing parts 102-108 µm, stipes 14-24 µm, apical ring present, refractive, inamyloid, 2.5-3 µm wide, sub-apical globulus absent. Perithecial contents whitish, slimy. **Paraphyses** fragile, nonpersistent, only visible in fresh material, 1.5-2 µm wide. **Ascospores** 48-58 x 3.5-3.8 µm (mean values: 51.8 x 3.5 µm), cylindrical, slightly sigmoid to almost straight, geniculate at the lower end at a variable angle and ending in a 6-7.5 µm long 0.7 µm wide spiny tip with a faintly swollen extremity, hyaline to yellowish, smooth, 1-3 septate at maturity, 2-4 seriate in the asci. Germination not observed. **Associated anamorph**: unknown but an *Endophragmiella* sp. may be present, conidiophores (80) – 120 – 270 µm long, 5 – 6.5 –(8) µm wide, straight, septate, dark brown, conidia broadly ellipsoid to pyriform, 20 – 23 x 12.5 – 14 µm, smooth, 2 – septate, the distal cells dark brown, the proximal cell paler.

Habitat: on rotten deciduous wood.
Etymology: from latin *rufus* (= rust), referring to the rusty perithecial color.

Specimens examined. FRANCE. Pyrénées Atlantiques (64). Oloron, Forêt Domaniale d'Oloron, on *Quercus*, 30 Aug. 1997, FC-5096-515. Oloron, Forêt de Bugangue, on deciduous wood, 5 Oct. 1997, FC-5096-541, (HOLOTYPE CUP-65603, ISOTYPE S F14583). Barthe de l'Hôpital Saint Blaise, vicin. Mauléon, on *Salix*, 27 Oct. 1998, FC-5096-638. Oloron, Parking area of Forêt d'Oloron, on *Quercus*, 10 Oct. 1999, FC-5096-673. Oloron, Lower area of Forêt d'Oloron, on *Quercus*, 31 Oct. 1999, FC-5096-680. Ariège (09). Rimont, Las Muros, Ruisseau de Peyrau, on *Alnus glutinosa*, 12 March 2000, JF-0055.

Discussion. An *Endophragmiella sp.* was present in five (FC-515, FC-541, FC-638, FC-673, JF-0055) of the six collections of *L. rufa* reported during this study, always growing on and between empty perithecia but was never found associated with young perithecia, as it is usually encountered in *L. punctata*. This last feature makes difficult to consider *Endophragmiella* more than an hyperparasite, although its relationship with *L. rufa* may be suspected.

Lasiosphaeria rufa may be easily mistaken for the red-brown form of *L. strigosa* and *L. canescens* with which it shares the perithecial shape, the stiff, acute, thick-walled, crowded setae, the undifferentiated apical area and the same peridial structure (and supposed association with an *Endophragmiella*). Despite these similarities, *L. rufa* differs in having a characteristic rust color and long cylindrical geniculate ascospores ending in a spiny tip in the lower third, whereas ascospores of *L. strigosa* and *L. canescens* are shorter and differently shaped, respectively narrowly allantoid in *L. canescens* and banana-shaped in *L. strigosa.* Other species of *Lasiosphaeria* with similar thick-walled setae are *L. pallida* and *L. stuppea,* both having bean-shaped ascospores, the former having a soft light brown peridium and the latter a leathery blackish peridium and a strongly tuberculate apex. Ascospores geniculate in the lower third ending in a spiny tip may be encountered in several other species of *Lasiosphaeria* such as *L. breviseta, L. caudata, L. meznaensis,* and *L. munkii*. *Lasiosphaeria breviseta* and *L. munkii* are similar to *L. rufa* in having thick-walled setae, and a similar peridial anatomy, they both differ mainly from *L. rufa* in having dark brown perithecia, in being much less setose and in having grey brown ascospores. Moreover *L. rufa* lacks the black conical ostiolar area found in *L. breviseta,* and ascospores of *L. munkii* are shorter and wider than those of *L. rufa* and the end of their spiny tip is distinctly enlarged.

Lasiosphaeria caudata differs obviously from *L. rufa* in having long, thin and flexuous setae and a ridged ostiolar area. *Lasiosphaeria meznaensis* differs from *L. rufa* in having shining black perithecia bearing light to dark brown setae and larger ascospores up to 8 – 10 – septate.

6 - ***Lasiosphaeria stuppea*** Ellis & Everh., Bull. Wash. Coll. Lab. Nat. Hist. I: 4, 1884. Figs. 7, 10-f, 11-f, 12-f, 13-c.

Perithecia scattered or in small groups, superficial, globose with a flattened base slightly sunken in the wood, with (2-) 3-4 strong tubercles at the top separated by deep furrows coming down towards the base, black, 480-700 µm in diam., 500-650 µm high, roughened in surface, setose; setae yellowish, dense in first stages and becoming sparse with increasing age, acute, stiff or flexuous and then drooping to the base, cylindrical with an acute apex and a slightly bulbous base, thick - walled, 80-200 (-270) µm long, 6.5-10 (-13) µm wide with a narrow lumen 1.5-5 µm wide, nonseptate. Apex nonpapillate, black, tuberculate, glabrous or setose, surrounding a flattened glabrous area where the ostiolar canal opens. Subiculum absent. **Peridium** tough leathery, blackish brown, 70-130 (-210) µm thick, two layered. *Outer layer* 50-80 µm thick (up to 185 µm thick in the portions between the furrows), *textura globosa-angularis* composed of 5-12 rows of thick - walled brown cells, 8-23 µm in diameter, wall 1.5-6.5 µm thick, mixed in the thickest parts with groups of rectangular cells perpendicular to the surface, 25-33 x 10-12 µm. *Inner layer* 13-32 µm thick, *textura prismatica* of hyaline thin-walled cells 10-28 x 2-5 µm. Tubercles surrounding the ostiolum 160-180 µm thick, composed of strongly melanized opaque cells of the outer layer. *Ostiolum* opening by a pore lined with numerous periphyses. **Asci** 8-spored, unitunicate, broadly fusiform, truncate at the apex, 142-180 µm long, the spore-bearing parts 92-120 x 18-22 µm, the stipes 37-69 µm. Apical ring refractive, double, inamyloid, 5-5.5 x 1.5-2 µm. Subapical globulus absent. **Paraphyses** numerous, cylindrical, hyaline, septate, 3-7.5 µm in diatameter. Perithecial contents whitish, slimy. **Ascospores** 23-34 x 6.8-11 µm (mean values: 30 x 8.6 µm), of variable shape ranging from wide allantoid to elliptic- inequilateral, slightly curved in the middle, with rounded or slightly conical ends, multiguttulate, yellowish to very light brown, minutely verruculose, 0-1(-2) septate, 1-2 seriate in the asci. Germination by germ tubes. **Anamorph** unknown.

Habitat: Saprobic on rotten coniferous or deciduous wood.

Specimens examined. USA. Mt. Adams, on *Tsuga mertensiana*, 16 Sept. 1883, WSU-27527. Horse Camp, Mt. Shasta, Siskiyou Co., Cal., on *Abies magnifica*, 31 July 1946, WSU-20308. Yakima Park, Mt. Rainier Nastional Park, Washington, on *Chamaecyparis nootkatensis*, 4 Aug. 1957, WSU-68177. FRANCE. Ariège (09). Rimont, Las Muros, Ruisseau de Peyrau, on decorticated wood of *Buxus sempervirens*, 12 Feb. 1997, JF-9720. Rimont, Las Muros, Ruisseau de Peyrau, on decorticated rotten wood of *Ulmus minor*, 28 Jan. 1998, JF-9803. Roquefixade, on decorticated wood of *Buxus sempervirens*, 15 Feb. 1998, JF-9817. Rimont, Las Muros, Ruisseau de Peyrau, on decorticated rotten wood of *Ulmus minor*, 20 Sept. 1999, JF-99220.

Discussion. *Lasiosphaeria stuppea* is a species formerly described from North America by Ellis & Everhart (1884). They have clearly described and illustrated its more striking characters such as the tow-colored setae, the strongly 4-ribbed ostiolum and the wide allantoid ascospores. Our four collections match well the type collection. Moreover we had opportunity to observe the following characters, not previously described: very thick peridium with numerous rows of strongly melanized cells, double apical ring, minutely verruculose wall of the ascospores, their tendency to have conical ends and their germination by germ tubes. *Lasiosphaeria stuppea* differs markedly from other known species of *Lasiosphaeria* in its thick to very thick strongly melanized peridium with differentiated tubercles at the top and vertical furrows on the side. Its bean-shaped ascospores, when they have rounded ends, resemble those of *L. pallida* but these two species are readily distinguished on the basis of the peridial color and morphology. When they are conical at the ends, its ascospores may be somewhat reminiscent of those of *L. strigosa* that, however, are longer and narrower, and illustrate possible transitions between different morphological types of ascospores. So far only known from North America and from Czech Republic (Réblová & Prášil

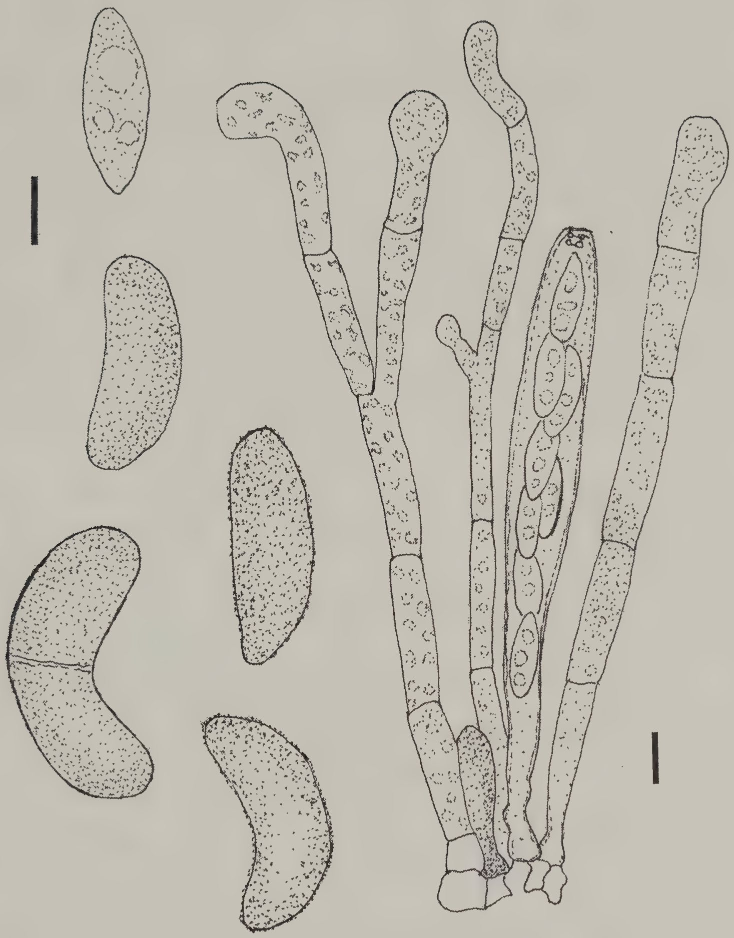

Figure 7: *L. stuppea.* Ascus, paraphyses and ascospores. Bars = 10 µm. From JF-9720.

1999), *L. stuppea* is reported for the first time from France. Its occurrence on dead wood of *Buxus sempervirens* is noteworthy as it is a very unusual substratum for the members of *Lasiosphaeria* we encountered during this study.

7 - *Lasiosphaeria vestita* F. Candoussau, J. Fournier & J.F. Magni, sp. nov., Figs. 8, 10-*g*, 11-*g*, 12-*g*.

Perithecia dispersa vel sparsim gregaria, superficialia, ovoidea vel obpyriformia, pallida brunnea vel atrobrunnea, minuta, 150-220 µm lata, 160-360 µm alta, totae praeter apicem dum juvenes tomento albido vel pallide flavo, sericeo vel lanato tecta. Hyphae tomenti 1.5-3.5 µm latae, hyalinae vel pallide coloratae. Apice perithecii ostiolato, nigro, parum vel valde distincto, cylindraceo vel acute conoideo, ad 70-90 µm lato et 70-80 µm alto. Peridium 35-70 µm latum, molle, membranaceum, pallide brunneum, duobus stratis compositum. Canalis ostioli dense periphysibus lineatus. Pars interior perithecii albida. Paraphyses numerosae, 1.5-2 µm latae, filiformes, septatae ramosaeque. Asci octospori, rarius 6-spori, 112-125 x 15-24 µm, brevistipitati, pars sporifera 100-110 µm, stipes 14-17 µm, ventricosi ad clavati, apice truncato. Annulus apicalis distinctus, inamyloideus, 2.5-3 µm latus. Globulus subapicalis irregularis, 3-3.5 µm latus. Ascosporae 30-43.5 x 5.5-7.5 µm (38.8 x 6.4 µm media dimensione), oblongae ad anguste ellipsodeae, in medio laeviter incurvatae, apicibus late vel anguste rotundatis, flavidae, laeves, ad 7-septatae, biseriatae ad irregulariter aggregatae in parte superiori sporifera. Phialides ex ascosporis orientes. Holotypus: Gallia, in regione dicta "Ariège, Rimont, Las Muros". In ligno *Corylus avellana*, 8 Jun. 1998, leg. J. Fournier, JF-9859, CUP-65604.

Perithecia scattered or sparsely gregarious, superficial, ovoid to obpyriforme, small-sized, 150-220 µm in diam., 160-360 µm high. When young, covered, except at the apex, with a white to pale yellow tomentum, copious, silky to woolly, radiating at the base of the perithecia and spreading over the substrate, progressively reduced with age. Hyphae of the tomentum subhyaline to light brown, 1.5-3.5 µm wide, flexuous, irregular, sparingly branched or diverticulate, septate, thin to moderately thick-walled, roughened by a material vanishing in 3% KOH. Apex ostiolate, blackish, weakly to strongly differentiated, then cylindrical or acutely conical, up to 80 µ high and 70-90 µm in diam. **Peridium** soft membranaceous, 35-70 µm thick, very light brown, two-layered. *Outer layer* 18-40 µm thick, *textura epidermoidea* of densely interwoven hyaline hyphae 1.5 µm wide, more loosely woven towards the outside. *Inner layer* 18-30 µm thick, *textura prismatica* of light brown cells 6-16 x 3-5 µm, the outer ones darker and wider, the inner ones lighter to hyaline and more flattened. *Apical* wall thickened up to 45 µm, composed of tightly aggregated dark brown hyphae 1.5 µm wide, coming from the pigmented part of the inner layer and converging to the top of the ostiolum. Ostiolar area surface composed of dark brown hyphae 2-2.5 µm wide with slightly enlarged and rounded protruding tips. Ostiolar canal densely periphysate. **Asci** (6-) 8-spored, unitunicate, ventricose to clavate, 112-125 x 15 -24 µm, short stipitate, spore-bearing parts 100-110 µm, stipes 14-17 µm, truncate at the apex, apical ring indistinct or absent, subapical globulus present, irregular, 3-3.5 µm wide. **Paraphyses** numerous, filiform, 1.5-2 µm wide, septate, ramified, longer than the asci. Perithecial contents yellowish. **Ascospores** 30-43.5 x 5.5-7.5 µm (mean values: 38.8 x 6.4 µm) oblong to narrowly elliptical, slightly curved in the middle, with widely to

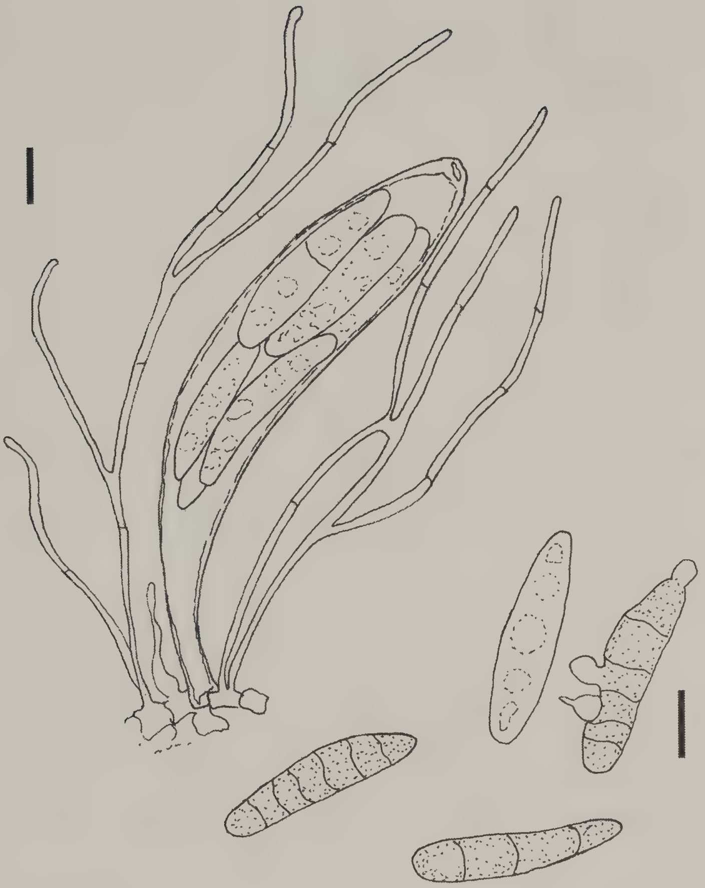

Figure 8: *L. vestita* (Holotype CUP-65604). Ascus, paraphyses and ascospores (one germinating ascospore). Bars = 10 µm.

narrowly rounded ends, light yellow, smooth, up to 7-septate, biseriate to irregularly clustered in the asci. Germination by phialides.
Anamorph : unknown.

Habitat: Saprobic on rotten wood lying on the ground.
Etymology: from latin *vestitus* (= covered), referring to the dense tomentum (on the perithecia).

Specimens examined. FRANCE. Pyrénées Atlantiques (64). Oloron, Forêt d'Oloron, on deciduous wood, 9 Nov. 1997, JFM-9770. Ariège (09). Rimont, Las Muros, on decorticated wood of *Corylus avellana*, 08 June 1998, JF-9859 (HOLOTYPE CUP-65604, ISOTYPE S F14581). Pech de Foix, on decorticated wood of *Quercus pubescens*, 19 Aug. 1999, leg. Nicolas de Munnik, JF-99218.

Discussion. *Lasiosphaeria vestita* shows affinities with other members of *Lasiosphaeria, L. capitata, L. chrysentera* and *L. ovina*, the type species, in having the same peridial structure characterized by an outer hyphal layer *textura epidermoidea* covered by a tomentum that is abundant in young stages and progressively disappears. Similarly oblong slightly curved ascospores are found in *L. capitata* and in *L. vestita* but the former has a caplike apex and a dark brown tomentum while the latter differs markedly in having a papillate apex, smaller perithecia and a white to yellowish tomentum. *Lasiosphaeria chrysentera* and *L. ovina* are similar to *L. vestita* in having a papillate apex and a white tomentum but they both differ in having larger perithecia, less developed tomentum, deep yellow perithecial contents, conspicuous apical ring and cylindrical sigmoid ascospores bearing fugacious hyaline appendages.

Two additional species described as having similarly shaped ascospores should be compared to *L. vestita: L. trichopus* has very small glabrous perithecia, said to be fringed around the base with short brown hyphae, while *L. sorbina*, peridium of which is not clearly described, differs in having larger perithecia and pinkish ascospores. A comparative study of our three collections leads us to point out a high variability in tomentum color (white to pale greenish – yellow) and in texture (woolly as in *L. ovina* to distinctly silky).When young, the small-sized perithecia are embedded in this copious tomentum and, in the field, may be easily overlooked.

8- *Lasiosphaeria volvestriana* F. Candoussau, J. Fournier & J.F. Magni, sp. nov., Figs. 9, 10-*h*, 11-*h*, 12-*h*, 13-*e*.

Perithecia dispersa vel parum gregaria, primum in ligno immersa collis minime protrudentibus, dein erumpentia ad superficialia globosa vel obpyriformia, nigra, 430-550 µm lata, 580-740 µm alta, fragilia, aspera, setosa. Setae flavidae, sparsae flexuosae, crassitunicatae, apicibus rotundatis, 30-200 x 5-8 µm. Apex perithecii ostiolatus, nigrus, late vel anguste conoideus, 80-100 x 100-110 µm. Peridium 40-50 µm latum, tenue, membranaceum, atrobrunneum, duobus stratis compositum. Pars interior perithecii hyalina ad albida. Paraphyses 1.5-2 µm diametro, filiformes ad ventricosae, septatae. Asci octospori, 113 – 130 x 15 - 21µm, brevistipitati, pars sporifera 95 - 114µm, fusiformes ad ventricosi, apice truncato. Annulus apicalis distinctus, refractivus, inamyloideus, 3 – 3. 5 x 1 – 1.5µm. Globulus subapicalis abest. Ascosporae 28.5-36.5 x 5.5-7.5 µm (33.2 x 6.4 µm media dimensione), cylindraceae, tertia parte basali geniculata, pars distalis ample rotundata ad laeviter conoidea, pars proximalis anguste conoidea, olivaceobrunneae, laeves, 1 (2)-3-(4)-septatae, 2-3(4)-seriatae. Holotypus: Gallia, in regione dicta "Ariège, Forêt de Sainte Croix Volvestre". In ligno *Abies alba*., 9 Apr. 2000, leg. J. Fournier, JF-0036, CUP-65605.

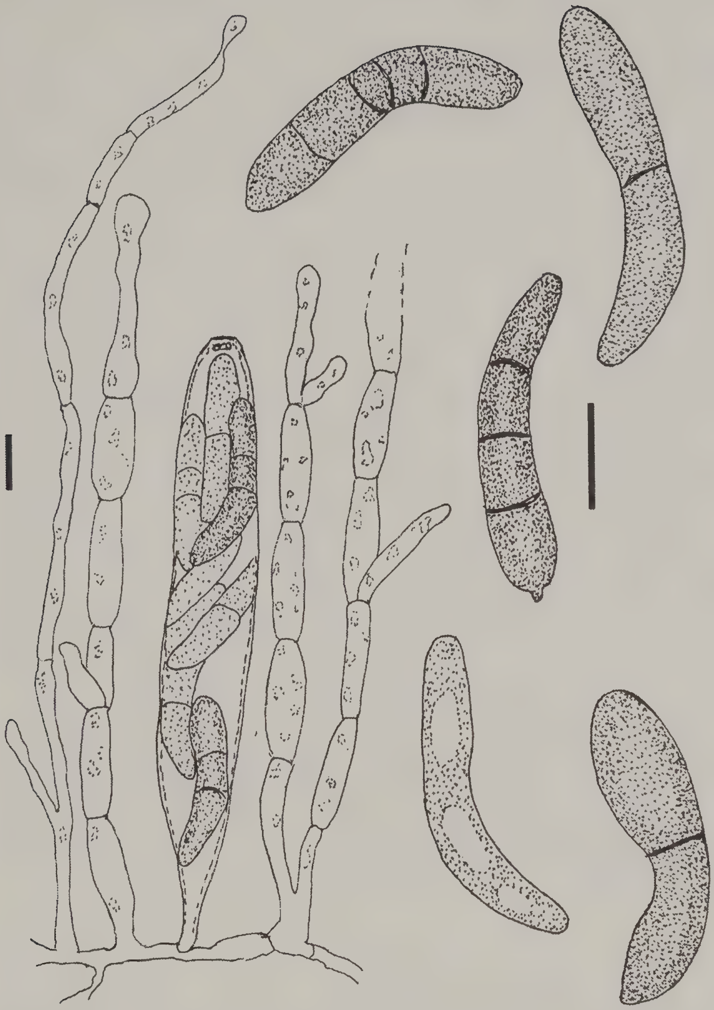

Figure 9: *L. volvestriana* (Holotype CUP-65605). Ascus, paraphyses and ascospores. Bars = 10 µm.

Perithecia scattered or in small groups, immersed in the wood with only the necks slightly protruding, becoming erumpent to superficial, globose to obpyriforme, black, 430-550 µm in diam., 580-740 high, fragile, laterally collapsing or not on drying, rough, setose. Setae yellowish, sparse, flexuous, drooping to the base, often contorted, septate, thick-walled with a lumen 1-3

µm wide, with rounded tips, 30-200 x 5-8 µm. Apex ostiolate, papillate, widely to narrowly conical, black, 80-100 µm in diam., 100-110 µm high, opening by a pore. True subiculum absent, but dark brown hyphae, 5-6.5 µm wide, septate, thick-walled, contorted, are present on the perithecial wall and in the surrounding substratum. **Peridium** soft, membranaceous, 40-50 µm thick, dark brown, two-layered. *Outer layer* 25-33µm thick, *textura angularis* composed of 2-6 rows of cells 8-18 x 6.5-13 µm, dark brown, thick-walled, wall 1.5(3) µm thick in the outermost rows, thin-walled and less pigmented in the deepest rows. *Inner layer* 15(25) µm thick, *textura prismatica* of hyaline to yellowish cells up to 25 x 3 µm. *In ostiolar neck*, the outer layer is thickened up to 40 µm, composed of small polyhedral thick-walled cells, strongly melanized, 8 x 6 µm, replaced at the apex by elongated, irregular, somewhat clavate cells, 19-26 x 5-8 µm, lying tangentially to the surface. Ostiolar canal densely periphysate. **Asci** 8-spored, unitunicate, fusiform to ventricose, 113-130 x 15-21 µm, short stipitate, the spore-bearing parts 95-114 µm, truncate at the apex, apical ring present, inamyloid, refractive, 3-3.5 x 1-1.5 µm. Subapical globulus absent. **Paraphyses** filiform to ventriculose, septate, 1.5-2 (-7) µm in diameter. Perithecial contents hyaline to whitish. **Ascospores** 28.5-36.5 x 5.5-7.5 µm, (mean values: 33.2 x 6.4 µm), cylindrical, geniculate in the lower third, the distal end broadly rounded to slightly conical, the proximal end more narrowly conical, without appendages, multiguttulate, olive brown to brown, already pigmented in the asci, smooth, 1-3(-4) septate, sometimes slightly constricted at the septa, 2-3(-4) seriate in the asci. The apical half of some ascospores may remain aseptate and then is distinctly swollen, giving an outline reminiscent of *Cercophora* ascospores, but never turn darker than the two basal cells. A rounded diverticle 1 x 1 µm may be rarely found at one or both ends of some ascospores .Germination not observed.
Anamorph unknown.

Habitat: Saprobic on very rotten wood of *Abies alba*, trunk lying on the ground.
Etymology: from ``Volvestre", referring to region of collection.
Specimens examined. FRANCE. Ariège (09). Forêt domaniale de Sainte Croix Volvestre, on very rotten wood of *Abies alba*, 9 April 2000, JF-0036,(HOLOTYPE CUP-65605, ISOTYPE S F14585); Forêt domaniale de Sainte Croix Volvestre, on very rotten wood of *Abies alba*, 17 March 2001, JF-01039.
Discussion. *Lasiosphaeria volvestriana* is well characterized by the combination of the following characters: perithecia immersed to erumpent, ostiolum papillate, smooth, narrowly conical, soft-walled peridium bearing thick-walled lightly pigmented blunt setae, olivaceous brown 3-septate

ascospores that are geniculate in the lower third and have rounded to conical ends.

L. volvestriana has to be compared to the other *Lasiosphaeria* bearing thick-walled setae and having brown geniculate ascospores, mainly *L. munkii*, *L. breviseta* and *L. moseri*. Ascospores of *L. munkii* and *L. breviseta* are geniculate in the lower third but are provided with an acute spiny tip. Moreover, ascospores of *L. munkii* differ in being shorter and narrower (23-32 x 3.5-4.5), hyaline to light brown and 0-1- septate, whereas ascospores of *L. breviseta* are longer and narrower (40-46 x 3.2-4) and 4(6)-septate. Ascospores of *L. moseri* are brown, geniculate, 3-(4) septate with a conical end, but differ in being longer (42-55) and narrower (4-4.6). Moreover, in *L. moseri*, perithecial wall is tuberculate, leathery, thick, and the ostiolar neck conspicuously ridged. It is noteworthy that these four species, beside their geniculate pigmented ascospores, show great affinities in anatomy of peridium and morphology of setae, and are apparently closely related. *Lasiosphaeria volvestriana* is reminiscent of *Lasiosphaeria glabrata*, redescribed by Munk (1957), which is said to be immersed to almost free, with a somewhat pellucid peridium and to bear short brownish hairs around the ostiolum. *Lasiosphaeria glabrata* differs in having glabrous perithecia, asci provided with an oblong subapical globulus, chrome – yellow perithecial contents and longer, narrower, hyaline sigmoid ascospores.

Other records

Lasiosphaeria sp. 1. Pyrenées Atlantiques (64). L'Ourtau, Bois du Bager, Oloron, on deciduous wood, 07 Nov. 1999, JFM-9987. This fungus appears to be intermediate between *L. munkii* and *L. breviseta*, with similar perithecia. It differs from *L. munkii* in having 3-septate ascospores that are already pigmented in asci, and from *L. breviseta* in having shorter and wider ascospores. This fungus might represent a new taxon but our collection is too small to be described as new.

Lasiosphaeria sp. 2. Haute Garonne (31). Fourquevaux, parc du château Palis, on *Acer campestre*, 07 Jul. 1999, JFM-9917. Asci, ascospores and brown subiculum are features of this species that are reminiscent of *L. pyramidata*. Perithecia differ from those of *L. pyramidata* in having coarsely pitted ostiolar necks, in being more or less covered by a brown tomentum and in having a nonareolate peridium. Unfortunately our collection is too small to be thoroughly studied.

Other rare species recorded for the first time from France. *L. breviseta.* P. Karst. Ariège (09). Rimont, Las Muros, Ruisseau de Peyrau, on rotten wood of *Alnus glutinosus*, 17 Aug. 2000, JF-00161. Bethmale, Forêt domaniale, Mont noir, 1400 m. a. s. l., on rotten wood of *Abies alba,* 22 Oct.

2000, JF-00243. Pyrénées Atlantiques (64). Forêt domaniale d'Oloron, on *Quercus*, 15 Aug. 1997, FC-5098-510. Gironde (33). Mongauzy, on deciduous wood, 28 Mar. 1999, JFM-9927.

L. caudata (Fuckel) Sacc. Ariège (09). Rimont, Las Muros, *on Quercus robur*, 03 Mar. 2001, JF-01025.

L. immersa P. Karst. Ariège (09). Gourbit, Lanouillade, 850m a. s. l., on *Populus*, 30 Apr. 2000, JF-0048. Rimont, Las Muros, Ruisseau de Peyrau, on *Ulmus minor*, 27 May 2000, JF-0065.

L. moseri O. Hilber. Gironde (33). Mongauzy, on *Ulmus*, 18 Oct. 1998, JFM-9832.

L. munkii Carroll & Munk. Pyrénées Atlantiques (64). Forêt domaniale d'Oloron, on *Quercus*, 25 Oct. 1996, FC-5098-555. Josbaig, Bois de Prechaq, on *Salix*, 21 Dec. 1997, FC-5098-559.

New French records of a rare species. *L. porifera* Réblová. Pyrénées Atlantiques (64). Bois de Josbaig, on rotten *Pinus silvestris* on the ground, 21 Dec. 1997, FC-5109-557. Ariège (09). Forêt domaniale de Sainte Croix Volvestre, on *Abies alba*, 09 Apr. 2000, leg Nicolas de Munnik, JF-0035.

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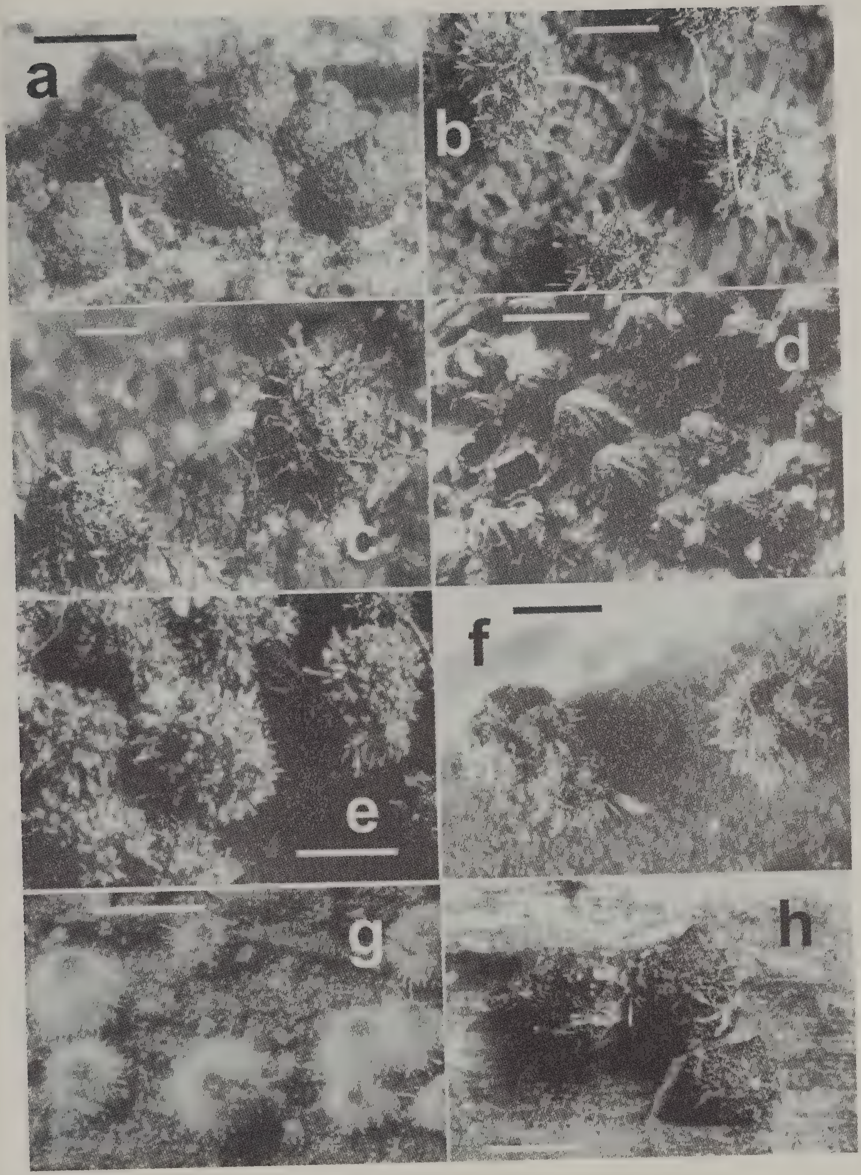

Figure 10: *a-h* Perithecia. 10-*a L. capitata*, 10-*b L. pallida*, 10-*c L. punctata*, 10-*d L. pyramidata*, 10-*e L. rufa*, 10-*f L. stuppea*, 10-*g L. vestita*, 10-*h L. volvestriana*. Bars = 0.4 mm in Fig. 10-*a*, 0.2 mm in Fig. 10-*c* and 0.5 in all other figures. *a,b,e,h* from holotypes, *c* from FC-5097-461, *d* from JFM-0001, *f* from JF-9720, *g* from JFM-9770.

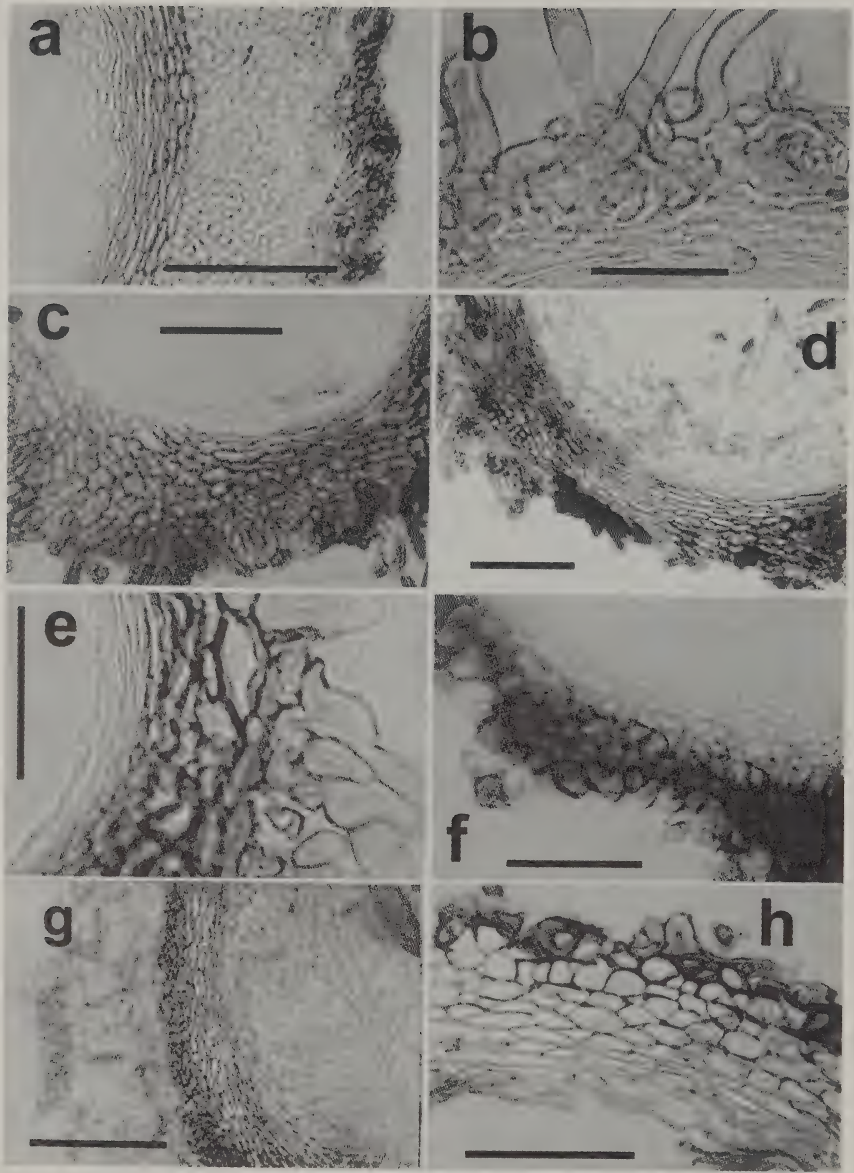

Figure 11: a-h Peridium structure. 11-*a L. capitata*, 11-*b L. pallida*, 11-*c L. punctata*, 11-*d L. pyramidata*, 11-*e L. rufa*, 11-*f L. stuppea*, 11-g *L. vestita*, 11-*h L. volvestriana*. Bars = 50 µm. *a,b,h* from holotypes, *c* from JF-98122, *d* from JFM-0001, *e* from FC-5096-673, *f* from JF-99220, *g* from JF-99218.

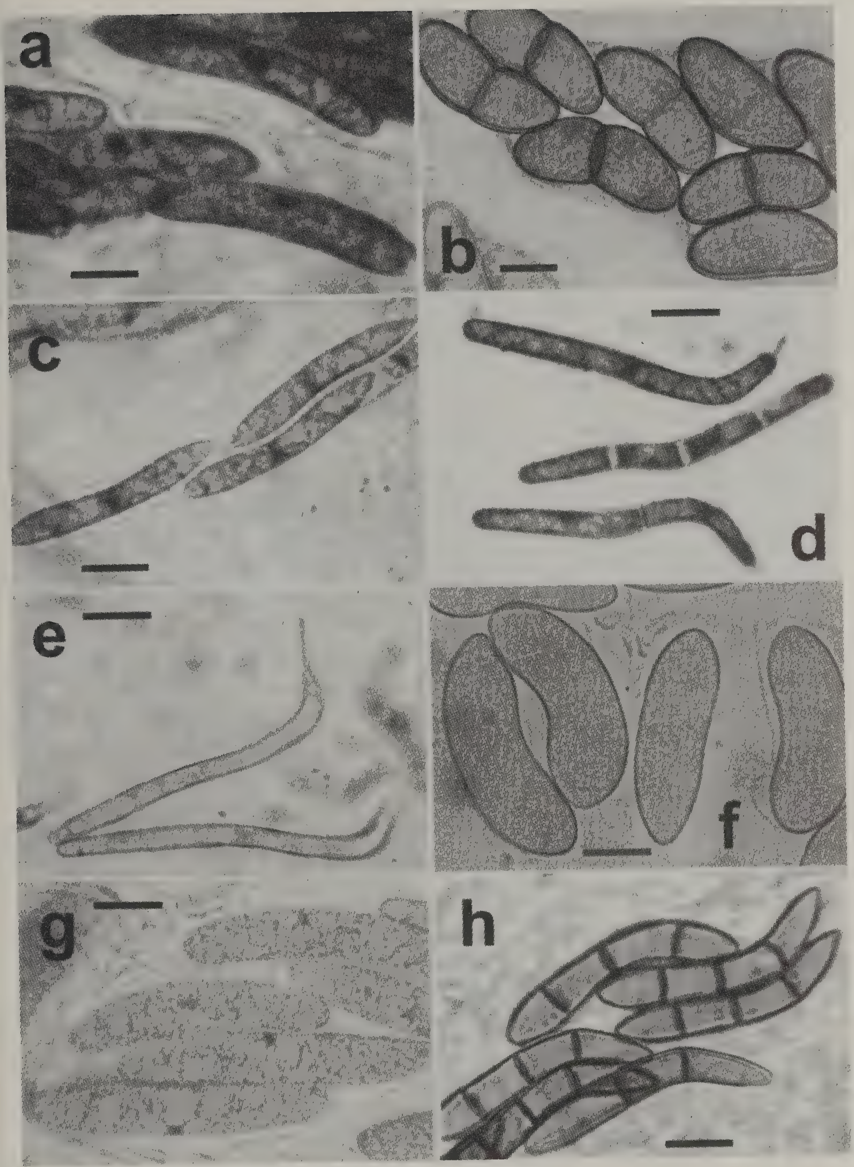

Figure 12: *a-h* Ascospores. 12-*a* *L. capitata*, 12-*b* *L. pallida*, 12-*c* *L. punctata*, 12-*d* *L. pyramidata*, 12-*e* *L. rufa*, 12-*f* *L. stuppea*, 12-*g* *L. vestita*, 12-*h* *L. volvestriana*. Bars = 10 µm. Photographs *a*, *c*, *d*, *e*, *f* and *g* are taken of preparations stained in lactic blue, *b* and *h* in lactophenol. *b*,*g*,*h* from holotypes, *a* from JF-99287, *c* from FC-5096-461, *d* from JFM-0001, *e* from FC-5096-515, *f* from JF-9720.

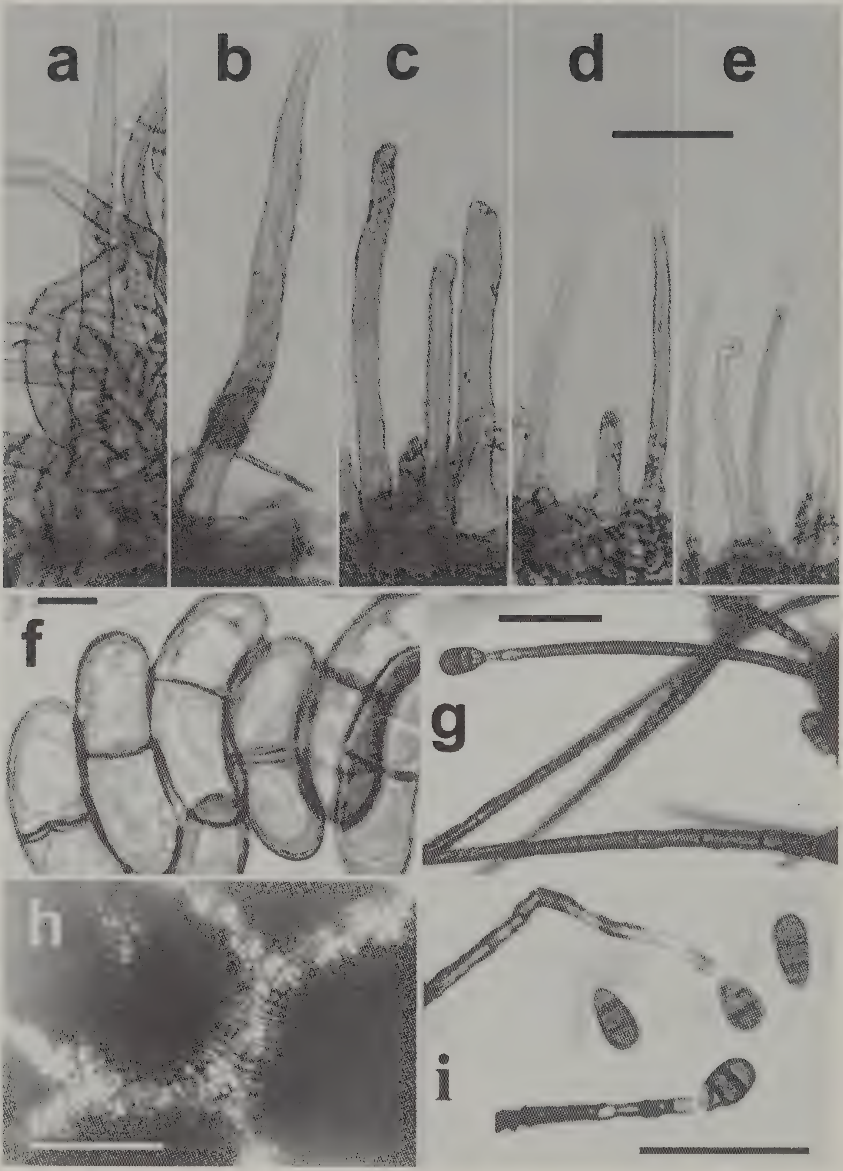

Figure 13: *a-e* Setae and *f-i* miscellaneous details. Setae: 13-*a* *L. pallida*, 13-*b* *L. punctata*, 13-*c* *L. stuppea*, 13-*d* *L. rufa*, 13-*e* *L. volvestriana*. 13-*f* *L. pallida*: immature ascospores, 13-*g* *L. punctata*: anamorph, 13-*h* *L. pyramidata*: areolate structure of the peridium, 13-*i* *L. rufa*: putative anamorph. Bars = 10 µ in Figs. 13-*f* and 13-*i*, 50 µm in all other figures. *a,e,f,i* holotypes, *b* from JF-9802, *c* from FC-5096-673, *d* from JF-99220, *g* from JFM-9974, *h* from JFM-0001.

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A CHECKLIST OF HIGHER MARINE FUNGI OF MEXICO

María C. González[1], Richard T. Hanlin[2], and Miguel Ulloa[1]

[1]Departamento de Botánica, Instituto de Biología,
Universidad Nacional Autónoma de México, México, DF 04510, México
mcgv@ibiologia.unam.mx
[2]Department of Plant Pathology, University of Georgia,
Athens, Georgia 30602-7274, USA
rhanlin@arches.uga.edu

Abstract: A checklist of Mexican higher marine fungi is presented, containing 47 ascomycetes, 1 basidiomycete and 14 mitosporic fungi. The fungi are listed from 17 localities on the Pacific Coast, 12 localities from the Gulf of Mexico Coast, and from 15 localities on the Caribbean Coast. Eleven new specimens from 18 Mexican beaches have been merged with the records from the literature. New records for Mexico are *Ceriosporopsis halima* and *Corollospora pseudopulchella.*

Keywords: Ascomycota, arenicolous fungi, Basidiomycota, biodiversity, mitosporic fungi, mycobiota

Resumen: Se presenta una lista de los hongos marinos de México que incluye 47 ascomicetes, 1 basidiomicete y 14 hongos mitospóricos. Los hongos enlistados provienen de 17 localidades de la costa del Pacífico, 12 de la costa del Golfo de México y 15 de la costa del mar Caribe. Los registros de la literatura se fusionaron con los datos de 11 nuevos especímenes recolectados de 18 playas mexicanas. Los registros nuevos para México son *Ceriosporopsis halima* y *Corollospora pseudopulchella.*

Introduction

The mycodiversity of Mexico remains unknown for the most part. In this country there probably exist 200 000 species of fungi but only 6 710 are recorded, and of those, 4 800 are macromycetes and 1 910 are micromycetes (Guzmán 1998). Consequently, the distribution of Mexican marine fungi is little known. The first collections of Mexican marine fungi were made in 1968 (Kohlmeyer 1968) and more data for this country have accumulated in the following years (Kohlmeyer 1969, 1983, 1984; Kohlmeyer and Kohlmeyer 1971, 1977; Kohlmeyer and Volkmann-Kohlmeyer 1987a, 1989, 1993; Hyde 1992; González and Herrera 1993, 1995; González et al. 1998). For this paper, the records from the literature have been merged with new data into a checklist of Mexican marine fungi. The checklist of higher marine fungi from Mexico contributes to the knowledge of the geographical distribution and occurrence of species from the coastal areas of Mexico.

Materials and Methods

The first author made new collections from 18 Mexican beaches. In order to obtain the fungi the techniques of Kohlmeyer and Kohlmeyer (1979) were followed. In the intertidal zone of each of the beaches, subtidal wood or washed-up detritus (wood pieces, algae and other debris) was collected, covered with moist sand from the collecting sites, and incubated in sterile hermetic plastic bags for 4–12 mo. When necessary, some samples were moistened with sterile artificial seawater to avoid drying out. The fungi were examined on natural substrates and then made into permanent slides according to the double cover glass method (Volkmann-Kohlmeyer and Kohlmeyer 1996). Photomicrographs were taken with an Olympus BH2–NIC for LM. All photographs were taken on Kodak Technical Pan 2415 film. Specimens are deposited as slides and/or dried material in the Herbario Nacional de Mexico (MEXU). For the checklist of Mexican marine fungi, an exhaustive literature review was performed. The records of the species of new collections were merged with the records from the literature. To designate a taxon as a new record for a Mexican state or the country of Mexico, published works were reviewed. Annotations on species examined are given only for the 11 new records. Each locality has been given a number referring to the list of localities (Table 1), and to the map (Fig. 1).

Results

Eleven species were recorded from sandy soil from Mexican beaches. *Arenariomyces parvulus, Ceriosporopsis halima, Corollospora pseudopulchella, Antennospora quadricornuta,* and *A. salina* are new records for the State of Veracruz and *Corollospora pseudopulchella* for the State of Quintana Roo. New records for Mexico are *Ceriosporopsis halima* and *Corollospora pseudopulchella*. Overall, *Corollospora maritima* was the most widely distributed (12 localities), followed by *Lindra thalassiae* (5 sites), which was found only on *Thalassia testudinum*. Concerning the mitosporic fungi, only *Trichocladium alopallonellum* and *Zalerion varium* were found on the sand beaches. The new collections were incorporated with the records from the literature, resulting in a checklist that includes 62 taxa (47 ascomycetes, 1 basidiomycete and 14 mitosporic fungi) from 44 different locations in Mexico. Annotations on the new collections examinated are given in the checklist.

Discussion

The morphology of ascospores of *Ceriosporopsis halima* from the Mexican collection are in agreement with the description of the type species. This species is mainly reported from temperate zones (Barghoorn and Linder 1944, Koch and Jones 1983, Koch and Petersen 1996) but it appears to have a world-wide distribution, because it also has been reported from tropical regions (Kohlmeyer and Volkmann-Kohlmeyer 1989). *Corollospora pseudopulchella* was originally described from seafoam collected at Ajigaura, Japan (Nakagiri and Tokura 1987). The ocean water temperature is the main factor determining the geographic distribution of *Corollospora* (Boyd and Kohlmeyer 1997, Bebout et al. 1987). Since this species is reported mainly from temperate areas, the ascospore morphology (ascopore size and septation, and the presence or absence of apical spines) of the Mexican collection (ascospores 68–95 × 8–10 μm, $\bar{x}$ = 80 × 8.5, n = 25) was compared with the Japanese species description (ascospores 65–97.5 × 7.5–11.5 μm)

Table 1. New collection sites and collecting locations from the literature, dates, and States of Mexico. In some geographic localities the information of collecting location is incomplete due to the lack of data in the published literature. Abbreviations were used for each collecting site. The locations numbers refer to Fig. 1.

1. CBS	Concepción Bay, 26° 45' 30" N, 111° 54' 45" W, 1 Apr. 1982, Baja California Sur.
2. PPS	Punta Púlpito, 26° 32' N, 111° 27' W, 2 Apr. 1982, Baja California Sur.
3. BCS	Puerto Ballandra, Carmen Island, 26° 01' N, 111° 11' W, 29 Mar. 1982, Baja Calif. Sur.
4. PCS	Punta Colorado, José Island, 25° 0' 45" N, 110° 33' 30" W, 4 Apr. 1982, Baja Calif. Sur.
5. ABS	Amortajada Bay, José Island, 24° 54' 15" N, 110° 34' W, 28 Mar. 1982, Baja Calif. Sur.
6. CYS	Coyote Bay, 26° 43' N, 111° 54' 30" W, 31 Mar. 1982, Baja California Sur.
7. PBS	Puerto Ballena, Espíritu Santo Island, 24° 27' N, 110° 20' W, 27 Mar. 1982, Baja California Sur.
8. LMJ	La Manzanilla, 19° 16' 56" N, 104° 47' 20" W, 2 May 1994, Jalisco.
9. BNJ	Barra de Navidad, 19° 12' N, 104° 41' 05" W, 20 Jul. 1991, 20 Apr. 1994*, Jalisco.
10. BLJ	Barra de Navidad Lagoon, 19° 10' 57" N, 104° 40' 55" W, 13 Nov. 1992, Jalisco.
11. ECC	El Coco, 19° 10' 12" N, 104° 39' 17" W, 4 Apr. 1995, Colima.
12. BSC	Olas Altas, Santiago Bay, 19° 07' 04" N, 104° 21' 48" W, 28 Jul. 1994, Colima.
13. BMC	Playa Azul, Manzanillo Bay, 19° 03' N, 104° 19' W, 19 Nov. 1994, Colima.
14. CYC	Cuyutlán, 18° 55' N, 104° 05' 13" W, 1 May 1994, Colima.
15. BPC	Near Boca de Pascuales, Cuyutlán, Mar. 1992, Colima.
16. LVO	La Ventosa, near Salina Cruz, 13 Mar. 1967, Oaxaca.
17. ACH	Puerto Arista, 18 Mar. 1967, Chiapas.
18. MIV	Miramar 21° 03' 35" N, 97° 47' 46" W, 22 Mar. 1995, Veracruz.
19. CRV	Casitas River, between Tecolutla and Nautla, 12 Feb. 1966, Veracruz.
20. ARV	San Agustín River, between Nautla and Veracruz, 12 Feb. 1966, Veracruz.
21. VMV	Villa del Mar, 19° 10' 34" N, 96° 06' 32" W, 23 Mar. 1995, Veracruz.
22. MBV	Mocambo, 19° 08' 56" N, 96º 05' 44" W, 23 Mar. 1995, Veracruz.
23. BRV	Boca del Río, 21 Mar. 1967, Veracruz.
24. ALV	Antón Lizardo, 19° 03' 42" N, 95° 59' 25" W, 24 Mar. 1995, Veracruz.
25. VAV	Km 24 Veracruz-Alvarado Highway, 18° 52' 30" N, 95° 55' W, 7 Apr. 1995, Veracruz.
26. AVV	Alvarado, 21 Mar. 1967, Veracruz.
27. MPV	Monte Pio, 18° 38' 43" N, 95° 05' 42" W, 11 Mar. 1995, Veracruz.
28. JIV	Jicacal, 18° 37' 13" N, 95° 04' W, 11 Mar. 1995, Veracruz.
29. PGY	Progreso, 21 Mar. 1970, Yucatán.
30. PSQ	Punta Sam, 21° 12' 47" N, 86° 47' 01" W, 27 Jun. 1994, Quintana Roo.
31. CCQ	Caracoles Beach, Cancún, 21° 08' 19" N, 86° 45' W, 20 Oct. 1995, Quintana Roo.
32. DBQ	Delfines Beach, Cancún, 21° 02' 57" N, 86° 46' 05" W, 10 Apr. 1995, Quintana Roo.
33. PMQ	Puerto Morelos, 20° 52' 14" N, 86° 52' W, 1 Jul. 1994, Quintana Roo.
34. PCQ	Playa del Carmen, 20° 37' 15" N, 87° 04' 25" W, 29 Jan. 1983, 5 Oct. 1993, Quintana R.
35. XHQ	Xelha, 20° 21' 30" N, 87° 21' W, 29 Jan. 1983, Quintana Roo.
36. TUQ	Tulum, 20° 12' 37" N, 87° 25' 48" W, 26 Jun. 1994, Quintana Roo.
37. BPQ	Boca Paila, 20° 06' N, 87° 28' 37" W, 28 Jun.1994, Quintana Roo.
38. MJQ	Majagual, 18° 42' 50" N, 87° 42' 31" W, 10 Oct.1993, Quintana Roo.
39. LCQ	Los Cocos Beach, Cozumel Island, 20° 29' N, 86° 49' W, 1 Feb. 1983, Quintana Roo.
40. EPQ	El Presidente, Cozumel Island, 20° 27' N, 87° W, 27 Jan. 1983, Quintana Roo.
41. PTQ	Punta Tormentos, Cozumel Island, 20° 25' 45" N, 87° 01' W, 1 Feb. 1983, 10 Feb. 1983, Quintana Roo.
42. SFQ	San Francisco Beach, Cozumel Island, 20° 21' 30" N, 87° 01' W, 28 Jan. 1983, Quintana Roo.
43. CRQ	Castillo Real, Cozumel Island, 20° 32' N, 86° 45' W, 1 Feb. 1983, Quintana Roo.
44. MCQ	Punta Morena, Cozumel Island, 20° 27' N, 86° 51' W, 28 Jan. 1983, 1 Feb. 1983, Quintana Roo.
45. PPS	Puerto Peñasco, Sonora.
46. GBN	Guadalupe Island, Baja California Norte.

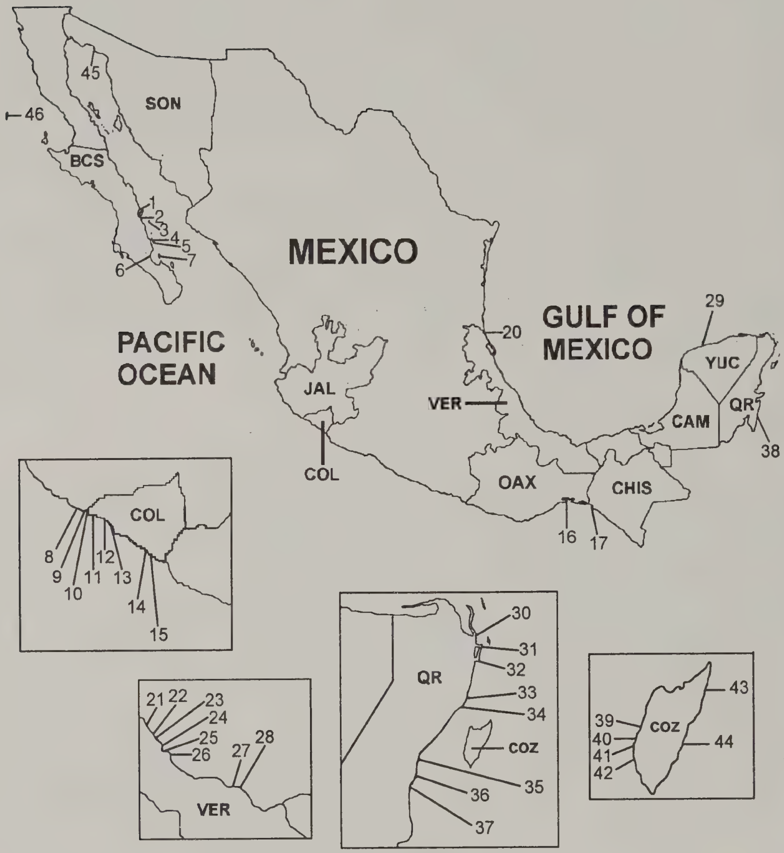
MEXICO
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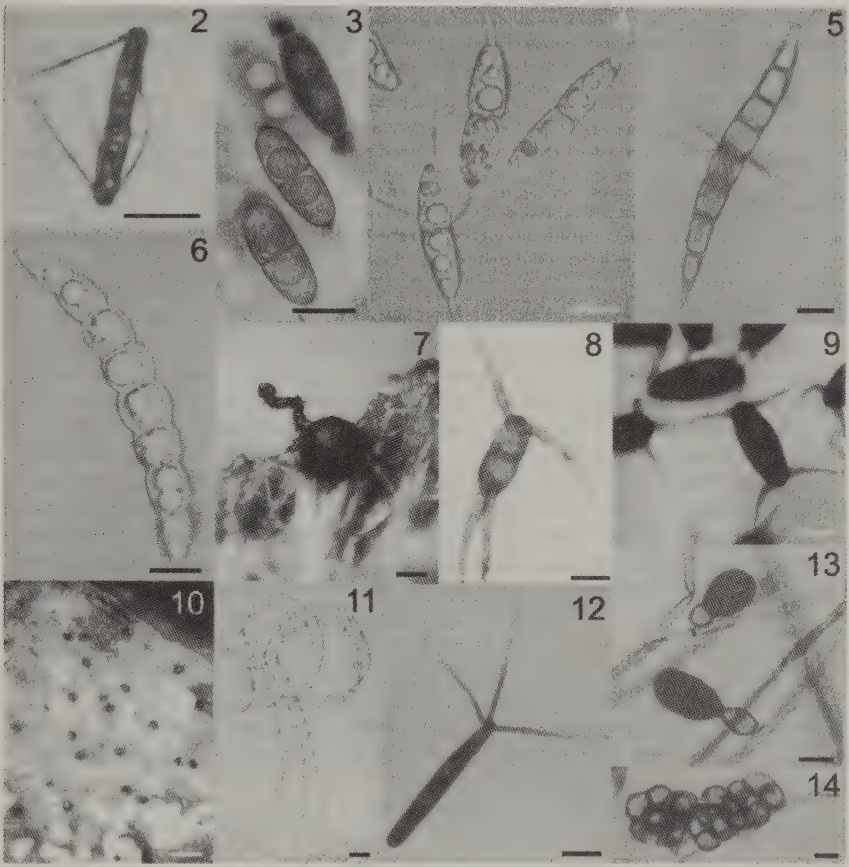
Fig. 1. Map of Mexico showing localities of the States of Mexico in which marine fungi are recorded. See list of localities, Table 1. State of Baja California Sur = BCS, State of Campeche = CAM, State of Chiapas = CHIS, State of Colima = COL, Island of Cozumel, State of Quintana Roo = COZ, State of Jalisco = JAL, State of Oaxaca = OAX, State of Quintana Roo = QR, State of Sonora = SON, State of Veracruz = VER, and State of Yucatán = YUC.



Figs. 2-6, 8-9, 11-12. Ascospores of the marine fungi from Mexico.
2. *Arenariomyces parvulus*. 3. *Ceriosporopsis halima*. 4. *Corollospora maritima*. 5. *Corollospora pseudopulchella*. 6. *Corollospora pulchella*. 8. *Antennospora quadricornuta*. 9. *Antennospora salina*. 11. *Lindra thalassiae*. 12. *Torpedospora radiata*.

Fig. 7. Ascoma of *Antennospora quadricornuta*. Fig. 10. Ascomata of *Lindra thalassiae* embedded in *Thalassia testudinum* leaf.

Figs. 13, 14. Mitospores of the marine fungi from Mexico.
13. *Trichocladium alopallonellum*. 14. *Zalerion varium*.

Scale bars Figs. 2-6, 8, 9, 11-14 = 10 μm, Fig. 7 = 100 μm, and Fig. 10 = 600 μm.
Figs. 3, 9, 12. Ascospores stained with gentian violet.

and the ascospore characters are in agreement. Several new collections are cosmopolitan species, such as *Corollospora maritima, C. pulchella, Torpedospora radiata, Trichocladium alopallonellum,* and *Zalerion varium*, whereas *Antennospora quadricornuta* and *A. salina* are widely distributed tropical species. Almost all new collections grow on driftwood or cellulosic debris. The only species that was associated with one substrate type was *Lindra thalassiae,* which occurred on leaves of the seagrass *Thalassia testudinum.*

The checklist contributes to knowledge of the geographical distribution and occurrence of marine species from Mexico. Although in Mexico the distribution of the marine mycobiota has not been studied as intensively as in other countries, such as Belize (Kohlmeyer and Volkmann-Kohlmeyer 1987b), Denmark (Koch 1974, Koch and Jones 1983, Koch and Petersen 1996), Japan (Tubaki 1966, 1967; Tokura 1982, 1984; Nakagiri and Tokura 1987), Malaysia (Jones 1989, Sundari et al. 1996), and the Hawaiian Islands (Kohlmeyer and Volkmann-Kohlmeyer 1987a, 1989; Volkmann-Kohlmeyer and Kohlmeyer 1993), it appears that the biodiversity is high, based on the results obtained in the 15 studies that have been undertaken. Hughes (1974) proposed 5 littoral mycogeographic zones: arctic, temperate, subtropical, tropical and antarctic. *Arenariomyces triseptatus, Falciformispora lignatilis, Lignincola tropica, Pontogeneia padinae* and *Cirrenalia pseudomacrocephala* were first described as new species from Mexican locations. The most widely distributed species in Mexico was *Corollospora maritima*, which is the most widely distributed cosmopolitan marine species, followed by *Lindra thalassiae.* The marine fungal biota of the nearly 11 000 km of coastline that Mexico has on the Pacific Ocean, the Gulf of Mexico and the Caribbean Sea is unknown for the most part. For that reason, it is necessary to continue studying the mycobiota of the marine coasts to contribute to the conservation and to knowledge of the biodiversity of microfungi from Mexico.

Checklist

Species are listed alphabetically by genus and species with information on collecting sites and substrates. In addition, data of 11 new collections made by the first author are included. New records from Mexico and new collections are marked with an asterisk.

Ascomycota

Aniptodera chesapeakensis Shearer et M. A. Mill., Mycologia 69: 894, 1977.
Mexican records: BPC, mangrove wood (Hyde 1992).

****Antennospora quadricornuta*** (Cribb et J. W. Cribb) T. W. Johnson, J. Elisha Mitchell Sci. Soc. 74: 46, 1958. Fig. 7, 8.
MPV, wood, MEXU 24476.
Mexican records: LVO, driftwood (Kohlmeyer 1968); CRQ, ascospores in foam; PTQ, wood; PCS, driftwood (Kohlmeyer 1984); BLJ, test panel of *Pinus sylvestris* (González and Herrera 1995).

****Antennospora salina*** (Meyers) T. W. Johnson, J. Elisha Mitchell Sci. Soc. 74: 46, 1958. Fig. 9.
ALV, MBV, detritus, incubated 4 mo, MEXU 24474, 24475.
Mexican records: LVO, ACH, driftwood (Kohlmeyer 1968, 1969); PCQ, tree trunk; LCQ, driftwood; MCQ, detritus; EPQ, tree trunk; PTQ, bamboo (Kohlmeyer 1984); DBQ, detritus

(González et al. 1998).

***Arenariomyces parvulus** W. J. Koch, Nordic J. Bot. 6: 497, 1986. Fig. 2.
TUQ, intertidal wood, incubated 6 mo, MEXU 24451; MPV, leaves of *Rhizophora mangle* from a tidal pool, incubated 10 mo, MEXU 24452.
Mexican records: no collection data given, Cozumel Island, State of Quintana Roo (Kohlmeyer and Volkmann-Kohlmeyer 1989); DBQ, leaves of *Sargassum* sp. (González et al. 1998).

Arenariomyces trifurcatus Höhnk, Veroeff. Inst. Meeresforsch. Bremerhaven 3: 30, 1954.
Mexican records: LVO, ascospores in foam (Kohlmeyer 1968); PGY, ascospores in foam (Kohlmeyer and Kohlmeyer 1971); CRQ, ascospores in foam; MCQ, intertidal detritus (Kohlmeyer 1984).

Arenariomyces triseptatus Kohlm., Mar. Ecol. (P.S.Z.N.I.) 5: 333, 1984.
Mexican records: PGY, ascospores in foam (Kohlmeyer and Kohlmeyer 1971); SFQ, algae, seagrass leaves, shell fragments and foraminiferan shells); MCQ, foraminiferans shells; LCQ, *Sargassum* sp. (Kohlmeyer 1984, Volkmann-Kohlmeyer and Kohlmeyer 1993).

Pharcidia balani (Nyl.) Arn., Ber. Bayer. Bot. Ges. 1 (Anhang): 121, 1891.
Mexican records: no collection data given, State of Sonora (Kohlmeyer and Kohlmeyer 1979).

Caryosporella rhizophorae Kohlm., Proc. Ind. Acad. Sci. (Plant. Sci.) 94: 356, 1985.
Mexican records: BPC, mangrove wood (Hyde 1992).

***Ceriosporopsis halima** Linder, Farlowia 1: 409, 1944. Fig. 3.
ALV, intertidal detritus, incubated 9 mo, MEXU 24453.

Corollospora angusta Nakagiri et Tokura, Trans. Mycol. Soc. Japan 28: 417, 1987.
Mexican records: VAV, detritus (González et al. 1998).

Corollospora gracilis Nakagiri et Tokura, Trans. Mycol. Soc. Japan 28: 426, 1987.
Mexican records: VAV, detritus (González et al. 1998).

Corollospora intermedia I. Schmidt, Nat. Naturschutz Mecklenburg 7: 6, 1969.
Mexican records: BNJ, detritus (González and Herrera 1993).

***Corollospora maritima** Werderm., Notizbl. Bot. Gart. Berlin 8: 248, 1922. Fig. 4.
In all collections ascomata on detritus: CCQ, PCQ, TUQ, BPQ, MIV, incubated 5 mo, MEXU 24456, 24457, 24458, 24459, 24460; VMV, JIV, MPV, incubated 10 mo, MEXU 24461, 24462, 24463; LMJ, BNJ, incubated 4 mo, MEXU 24464, 24465; BSC, BMC, incubated 4 mo, MEXU 24466, 24467; CYC, incubated 8 mo, MEXU 24468.
Mexican records: LVO, ascospores in foam (Kohlmeyer 1968); PGY, ascospores in foam (Kohlmeyer and Kohlmeyer 1971); CRQ, ascospores in foam; LCQ, bryozoan skeletons on *Sargassum* sp.; SFQ, algae and seagrass leaves; PTQ, crustose algae; CYS, PPS ascospores in foam (Kohlmeyer 1984); BNJ, detritus (González and Herrera

1993); DBQ, VAV, ECC detritus (González et al. 1998).

****Corollospora pseudopulchella*** Nakagiri et Tokura, Trans. Mycol. Soc. Japan 28: 428, 1987. Fig. 5.
MJQ, detritus, incubated 4 mo, MEXU 24473.

****Corollospora pulchella*** Kohlm., I. Schmidt et N. B. Nair, Ber. Dtsch. Bot. Ges. 80: 98-99, 1967. Fig. 6.
MJQ, TUQ, MPV, detritus, incubated 4 mo, MEXU 24470, 24471, 24472.
Mexican records: LVO, ascospores in foam (Kohlmeyer 1968, 1969); CRQ, ascospores in foam; MCQ, detritus (Kohlmeyer 1984); BPC, mangrove wood, (Hyde 1992); DBQ, ECC, detritus (González et al. 1998).

Dactylospora haliotrepha (Kohlm. et E. Kohlm.) Hafellner, Beih. Nova Hedwigia 62: 111, 1979.
Mexican records: ABS, on *Rhizophora mangle* (Kohlmeyer 1983); BPC, mangrove wood (Hyde 1992).

Etheirophora blepharospora (Kohlm. et E. Kohlm.) Kohlm. et Volkm.-Kohlm., Mycol. Res. 92: 415, 1989.
Mexican records: ARV, proproots of *Rhizophora mangle*; BRV, seedling of *R. mangle*, (Kohlmeyer 1968).

Falciformispora lignatilis K. D. Hyde, Mycol. Res. 96: 25-30, 1992.
Mexican records: BPC, mangrove wood (Hyde 1992).

Halosarpheia abonnis Kohlm., Mar. Ecol. (P.S.Z.N.I) 5: 339, 1984.
Mexican records: CYS, driftwood and branch of *Avicennia germinans*; PBS, wood of *A. germinans* (Kohlmeyer 1984).

Halosarpheia marina (Cribb et J. W. Cribb) Kohlm., Mar. Ecol. (P.S.Z.N.I) 5: 345, 1984.
Mexican records: BPC, mangrove wood (Hyde 1992).

Halosphaeria cucullata (Kohlm.) Kohlm., Can. J. Bot. 50: 1956, 1972.
Mexican records: LVO, driftwood (Kohlmeyer 1969).

Halosphaeriopsis mediosetigera (Cribb et J. W. Cribb) T. W. Johnson, J. Elisha Mitchell Sci. Soc. 74: 44, 1958.
Mexican records: CRV, pneumatophores of *Avicennia nitida* (Kohlmeyer 1968).

Hydronectria tethys Kohlm. et E. Kohlm., Nova Hedwigia 9: 95, 1965.
Mexican records: PTQ, branch of *Conocarpus erecta* (Kohlmeyer 1984).

Leptosphaeria australiensis (Cribb et J. W. Cribb) G. C. Hughes, Syesis 2: 132, 1969.
Mexican records: CYS, pneumatophores and branch of *Avicennia germinans*; PBS, root or branch of *A. germinans*; ABS, proproots of *Rhizophora mangle*; EPQ, tree trunk; PTQ, branch of *Conocarpus erecta* and subtidal (Kohlmeyer 1984).

Leptosphaeria avicenniae Kohlm. et E. Kohlm., Nova Hedwigia 9: 981,1965.

See Errata

Mexican records: BRV, pneumatophores of *Avicennia nitida* (Kohlmeyer 1968).

Lignincola leavis Höhnk, Veroeff. Inst. Meeresforsch. Bremerhaven 3: 216, 1955.
Mexican records: BPC, mangrove wood (Hyde 1992).

Lignincola tropica Kohlm. Mar. Ecol. (P.S.Z.N.I.) 5: 355, 1984.
Mexican records: PTQ, wood; EPQ, tree trunk (Kohlmeyer 1984).

Lindra crassa (Kohlm.) Kohlm. et Volkm.-Kohlm. Bot. Mar. 34: 23, 1991.
Mexican records: CRQ, ascospores in foam; MCQ, shell fragments attached to washed-up algae (Kohlmeyer 1984).

Lindra marinera Meyers, Mycologia 61: 488, 1969.
Mexican records: PGY, ascospores in foam (Kohlmeyer and Kohlmeyer 1971); VAV, detritus (González et al. 1998).

***Lindra thalassiae** Orpurt, Meyers, Boral et Simms, Bull. Mar. Sci. Gulf Caribb. 14: 406, 1964. Fig. 10, 11.
All ascomata on dead leaves of *Thalassia testudinum*: BPQ, CCQ, PMQ, incubated 4 mo, MEXU 24477, 24478, 24479; PSQ TUQ, incubated 5 mo, MEXU 24480, 24481.
Mexican records: BCS, ascospores in foam; LCQ, bryozoan skeletons; SFQ, calcareous alga; PTQ, leaves of *Thalassia testudinum* (Kohlmeyer 1984); DBQ, leaves of *T. testudinum*,; VAV, same substrate (González et al. 1998).

Lineolata rhizophorae (Kohlm. et E. Kohlm.) Kohlm. et Volkm.-Kohlm. Mycol Res 94: 688, 1990.
Mexican records: ABS, proproot of *Rhizophora mangle* (Kohlmeyer 1984).

Lulworthia sp.
Mexican records: CYS, pneumatophores of *Avicennia germinans*; PCS, subtidal wood; EPQ, branch (Kohlmeyer 1984); BLJ, wood (González and Herrera 1995).

Lulworthia grandispora Meyers, Mycologia 49: 513, 1957.
Mexican records: ABS, proproots of *Rhizophora mangle* (Kohlmeyer 1984); BPC, mangrove wood (Hyde 1992); BLJ, test panels of *Pinus sylvestris* (González and Herrera 1995).

Lulworthia kniepii Kohlm., Nova Hedwigia 6: 140-141, 1963.
Mexican records: CBS, coralline alga; PBS, coralline alga (Kohlmeyer 1984).

Massarina thalassiae Kohlm. et Volkm.-Kohlm., Can. J. Bot. 65: 575, 1987.
Mexican records: PBS, branch of *Avicennia germinans* (Kohlmeyer and Volkmann-Kohlmeyer 1987a).

Mycosphaerella pneumatophorae Kohlm., Ber. Dtsch. Bot. Ges. 79: 32, 1966.
Mexican records: BRV, pneumatophores of *Avicennia nitida* (Kohlmeyer 1968).

Mycosphaerella salicorniae (Auersw.) Petr., Hedwigia 74: 35, 1934.
Mexican records (all in *Salicornia* sp.): PGY (Kohlmeyer 1980); ABS (Kohlmeyer 1984).

Ocostaspora apilongissima E. B. J. Jones, R. G. Johnson et S. T. Moss, Bot. Mar. 26: 354, 1983.
Mexican records: BPC, mangrove wood (Hyde 1992).

Paraliomyces lentiferus Kohlm., Nova Hedwigia 1: 81 - 82, 1959.
Mexican records: AVV, roots of *Avicennia nitida* (Kohlmeyer 1968).

Pontogeneia codiicola (E.Y. Dawson) Kohlm. et E. Kohlm., Marine Mycology, Academic Press, p. 350, 1979.
Mexican records: Guadalupe Island, Baja California, *Codium fragile* and *C. simulans* on rocks (Dawson 1949).

Pontogeneia padinae Kohlm., Bot. Jahhrb. 96: 201, 1975.
Mexican records: Puerto Peñasco, Sonora, Mexico, on rhizoids of *Padina durvillaei* (Kohlmeyer, 1975).

Quintaria lignatilis (Kohlm.) Kohlm. et Volkm.-Kohlm., Bot. Mar 34: 35, 1991.
Mexican records: BPC, mangrove wood (Hyde 1992).

Remispora galerita Tubaki, Publ. Seto Mar. Biol. Lab. 15: 362, 1968.
Mexican records: PGY (Kohlmeyer and Kohlmeyer 1971).

Savoryella lignicola E. B. J. Jones et R. A. Eaton, Trans. Br. mycol. Soc. 52: 162, 1969.
Mexican records: BPC, mangrove wood (Hyde 1992).

Trematosphaeria lineolatispora K. D. Hyde, Mycol. Res. 96: 25-30,1992.
Mexican records: BPC, mangrove wood (Hyde 1992).

****Torpedospora radiata*** Meyers, Mycologia 49: 496, 1957. Fig. 12.
MPV, leaves of *Rhizophora mangle* from a tidal pool, MEXU 24482.
Mexican records: BRV, proproot of *Rhizophora mangle* (Kohlmeyer 1968); PGY, wood; same location, ascospores in foam (Kohlmeyer and Kohlmeyer 1971); CRQ, wood; XHQ, wood (Kohlmeyer 1984); ECC, detritus (González et al. 1998).

Verruculina enalia (Kohlm.) Kohlm. et Volkm.-Kohlm., Myc. Res. 94: 689, 1990.
Mexican records: ARV, proproot of *Rhizophora mangle*; CRV, driftwood; BRV, pneumatophores of *Avicennia nitida*, J. K. 1958; AVV, roots and pneumatophores of *A. nitida* and driftwood (Kohlmeyer 1968); PGY, wood (Kohlmeyer and Kohlmeyer 1971); BPC, wood (Hyde 1992); ECC, wood (González et al. 1998).

Basidiomycota

Nia vibrissa R. T. Moore et Meyers, Mycologia 51: 874, 1959.
Mexican records: CRQ, basidiospores in sea foam (Kohlmeyer 1984).

Mitosporic Fungi

Camarosporium roumeguerii Sacc., Michelia 2: 112 - 113, 1880.
Mexican records: no collection data given, State of Sonora (Kohlmeyer and Kohlmeyer 1979).

Cirrenalia pygmea Kohlm., Ber. Dtsch. Bot. Ges. 79: 35, 1966.
Mexican records: ACH, driftwood (Kohlmeyer 1968).

Cirrenalia pseudomacrocephala Kohlm., Mycologia 60: 266, 1968.
Mexican records: CRV, driftwood (Kohlmeyer 1968).

Cirrenalia tropicalis Kohlm., Mycologia 60: 267, 1968.
Mexican records: ECC, detritus (González et al. 1998).

Cytospora rhizophorae Kohlm. et E. Kohlm., Mycologia 63: 847-848, 1971.
Mexican records: AVV, *Rhizophora mangle* (Kohlmeyer and Kohlmeyer 1971); MCQ, seedling of *Rhizophora mangle*; EPQ, *R. mangle* (Kohlmeyer 1984).

Dendryphiella arenaria Nicot, Rev. Mycol. 23: 93, 1958.
Mexican records: ECC, detritus (González et al. 1998).

Dictyosporium pelagicum (Linder) G. C. Hughes, Fungi in Oceans and Estuaries, Cramer, p. 391, 1961.
Mexican records: BPC, mangrove wood (Hyde 1992).

Monodictys pelagica (R. G. Johnson) E. B. G. Jones, Trans. Br. mycol. Soc. 46: 138, 1963.
Mexican records: BPC, mangrove wood, (Hyde 1992).

Periconia prolifica Anastasiou, Nova Hedwigia 6: 260, 1963.
Mexican records: LVO, drifwood (Kohlmeyer 1969); EPQ, wood (Kohlmeyer 1984); BPC, mangrove wood (Hyde 1992).

Rhabdospora avicenniae Kohlm. et E. Kohlm., Mycologia 63: 851, 1971.
Mexican records: CYS, pneumatophores of *Avicennia germinans* (Kohlmeyer 1984).

Trichocladium achrasporum (Meyers et R. T. Moore) Dixon, Mycologia 63: 249, 1971.
Mexican records: CRV, wood core of pneumatophores of *Avicennia nitida*, J. K. 2443 (Kohlmeyer 1968, 1980; Kohlmeyer and Kohlmeyer 1979).

*~~~~***Trichocladium alopallonellum*** (Meyers et R. T. Moore) Kohlm. et Volkm.-Kohlm. Mycotaxon 53: 352, 1995. Fig. 13.
BNJ* intertidal detritus, MEXU 24484.
Mexican records: XHQ, wood (Kohlmeyer 1984); BLJ, test blocks of *Pinus sylvestris* wood (González and Herrera 1995).

Varicosporina ramulosa Meyers et Kohlm., Can. J. Bot. 43: 916, 1965.
Mexican records: PGY, conidia in foam (Kohlmeyer and Kohlmeyer 1971); CRQ, conidia in foam; LCQ, *Sargassum* sp. (Kohlmeyer 1984); VAV, detritus (González et al. 1998).

*~~~~***Zalerion varium*** Anastasiou, Can. J. Bot. 41: 1136, 1963. Fig. 14.
BNJ, intertidal wood, MEXU 24485.
Mexican records: BLJ, test blocks of *Pinus sylvestris* (González and Herrera 1995).

Acknowledgments

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MYCOTAXON

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A new species of Septobasidium from Costa Rica

Luis D.Gómez[1] and Liuba Kisimova- Horovitz[2]

[1]Academia Nacional de Ciencias, Costa Rica, Aptdo 676-2050
Costa Rica, e-mail: ldgomez@hortus.ots.ac.cr
[2]Am Dorfbrunnen 7, D-72070 Tübingen, Germany,
e-mail: sim@dimir.de

Abstract: *Septobasidium wilsonianum* associated with scale insects (Diaspididae, Coccoidea, Homoptera) attached to *Topobea multiflora*, Melastomataceae, is described and illustrated as a new species. It is the first report of a species of *Septobasidium* occuring on a member of the Melastomataceae.

Key Words: Septobasidiaceae, Melastomataceae, taxonomy.

During research on the Costa Rican species of *Septobasidium* Pat., a species was found associated with scale insects (Diaspididae, Coccoidea, Homoptera) attached to *Topobea multiflora*, (D. Don) Triana (Melastomataceae), which is described here as new.
The freshly collected material was studied with a Zeiss light microscope. Phloxin B was used as stain of the hand-sections or squash-mountings slides in H_2O or 5% KOH. The drawings were made with the aid of a Zeiss camera lucida.

Septobasidium wilsonianum L.D. Gómez & Kisimova *sp. nov.*
(Figs. 1-2)

Etymology: Named in honour of the founders of the Wilson Botanical Garden Robert and Catherine Wilson

Basidioma hypophyllicum, resupinatum, brunneum, e partibus duabus compositum. Pars prima in angulo nervorum folii, 5-10 mm lata, irregulariter porosa, plerumque sterilis, e subiculo et strato supero constans. Subiculum indistinctum, 10-15 µm crassum, hyphis 4-5 µm latis, tenuitunicatis, sparse septatis, efibulatis, brunneis. Stratum superum 0.5-2 mm crassum hyphis brunneis, 4-6 µm latis, fasciculatis, spinas implexas formantibus.

Pars secunda fertilis, e margine subiculi oriens, 3-40 mm longa, 5-18 µm crassa, unistratosa, in conditione arida a substrato faciliter separabilis, hyphis horizontalibus, ramosis, 3-7 µm latis, brunneis, probasidia et basidia singularia numerosa efferentibus. Probasidia globosa, 10-12 µm diametro, hyalina, persistentia. Basidia cylindrica, recta, 6-7 x 30-40 µm, transverse septata, 4-cellulata. Sterigmata 2,5-3 x 3.5-4 µm. Basidiosporae 3.5-5 x 12-17 µm, 1-3 septatae, hyalinae, allantoideae, hyphis vel gemmis germinant.

Fruitbodies resupinate, initially appear as minute brownish patches between the basal veins on the abaxial surface of the leaves . Mature basidioma composed of two areas:

First area confined to the little caves and basal parts of the veins with hirsute epidermis. Basidioma 5-10 mm long, with determinate margin, composed of two rather indifferentiated layers. Lower layer (subiculum), indistinct 10-15 µm thick, hyphae brownish, 4-5 µm in diameter, thin-walled, with a few septa and anastomoses.

Upper layer 0.5-2 mm thick formed by laxly interwoven brownish hyphae, hyphae 4-6 µm in diameter, straight and rarely branching, forming tangled thin spines, giving the surface an irregular porous appearance. This area is always sterile.

The second area extends from the margin of the first area over the glabrous epidermis as a thin horizontal layer of brownish hyphae, hyphae 3-7 µm in diameter, several branching and anastomosing, some becoming thick-walled. This layer is 5-18 µm thick, with margin indeterminate and of a lighter color, at favourable conditions extending to 30-40 x 20-30 mm, dropping off easily under dry conditions. On this flat area numerous probasidia and basidia are formed. Probasidia sphaerical, 10-12 µm diam., hyaline, persistent. Basidia cylindrical, 6-7 x 30-40 µm, straight or rarely slightly bent, 4-celled, sterigmata 2,5-3 x 3.5-4 µm. Spores 3.5-5 x 12-17 µm, hyaline, allantoid, 1-3 septate, germinating with hyphae or budding with yeasts.

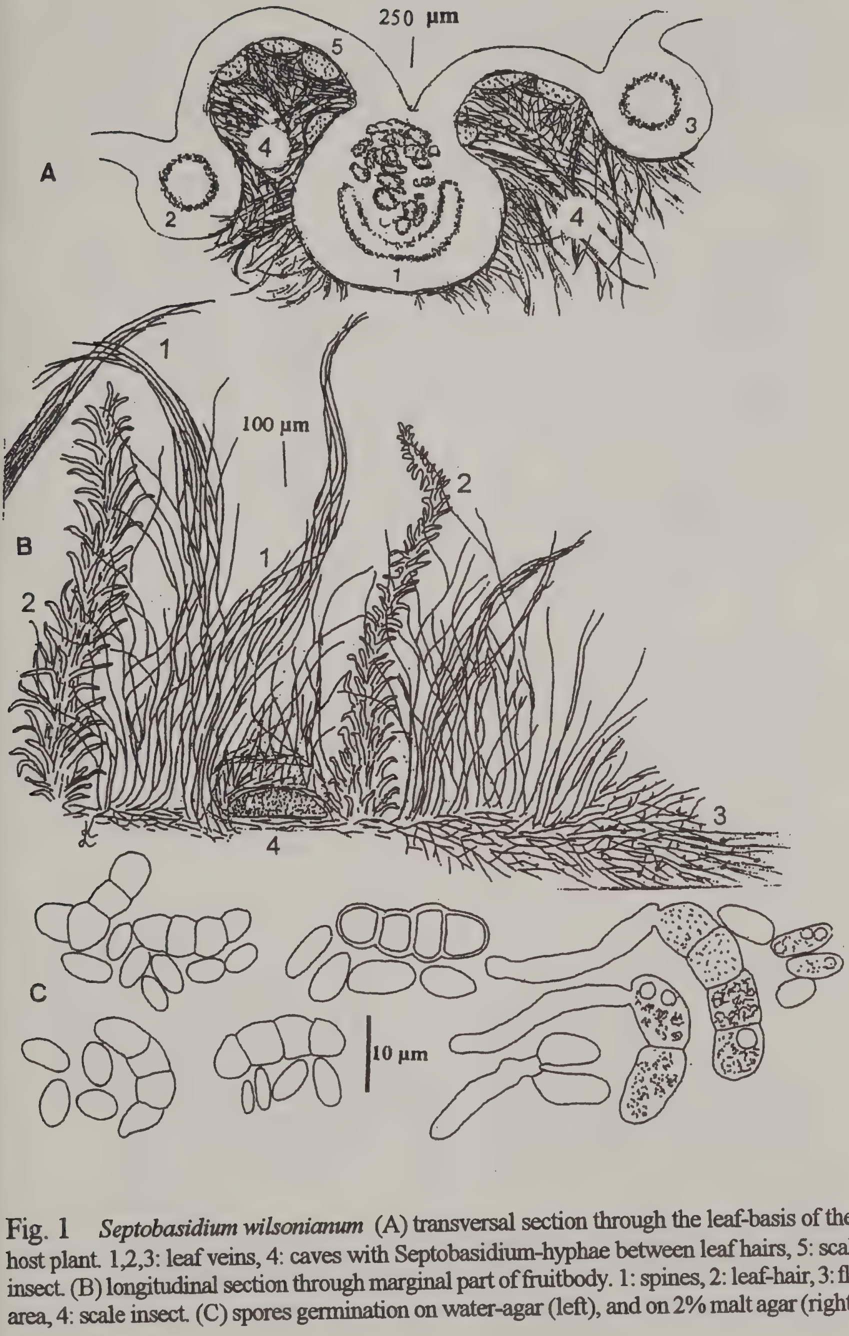

Fig. 1 *Septobasidium wilsonianum* (A) transversal section through the leaf-basis of the host plant. 1,2,3: leaf veins, 4: caves with Septobasidium-hyphae between leaf hairs, 5: scale insect. (B) longitudinal section through marginal part of fruitbody. 1: spines, 2: leaf-hair, 3: flat area, 4: scale insect. (C) spores germination on water-agar (left), and on 2% malt agar (right).

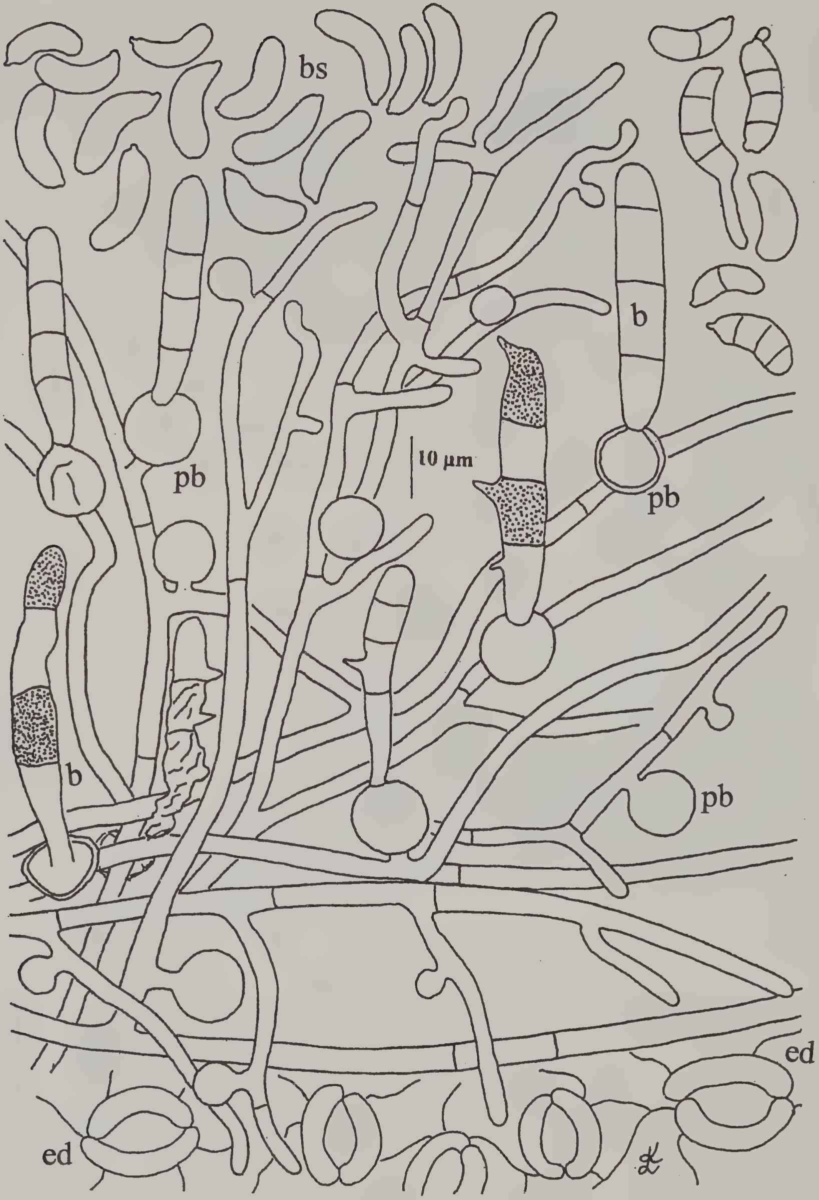
bs
b
10 µm
pb
pb
b
pb
ed
ed

Fig.2 *Septobasidium wilsonianum* flat area. Generative hyphae on leaf-epidermis (ed), probasidia (pb), basidia (b), basidiospores (bs).

Holotypus: On leaves of *Topobea multiflora* (D. Don) Triana (Melastomataceae), Wilson Botanical Garden, 1000 m above sea level, Coto Brus, Puntarenas, Costa Rica, leg. L.Kisimova-Horovitz, February 7th, 1998 (LKH-217-VII), deposited in Herbario Escuela de Biologia Universidad de Costa Rica, San Jose, USJ-55663.
Isotypus: item, February 13th, 2001 (LKH-75-VIII), USJ-55663a.

The new species resembles *S. curtisii* (Berk. et Desm.) Boedijn et Stein. (Boedijn et Steinmann, 1931: 181; Couch, 1938: 164, 326) in the spiny, papery appearance and *S. lepidosaphis* Couch (Couch, 1938: 146, 332, 432) in the general habit. It differs from both in the host plant and Coccids (Schmutterer, 1959), in the location on the host plant, size and structure of the fruitbodies and measurements of the basidia and basidiospores.
Septobasidium wilsonianum seams to be strongly associated with *Topobea multiflora* and was not observed to associate with other, not even close standing, Melastomataceae *Miconia* and *Blakea*.

Acknowledgment

The authors are grateful to Dr. F. Almeda (California, USA) for the identification of the host plant, to Dr. M. Weiß (Tübingen, Germany) for the Latin diagnosis and Dr. R. Berndt (Tübingen, Germany) for critically reading the manuscript and serving as pre-submission reviewer.

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STUDIES IN NEOTROPICAL POLYPORES 11: ANTRODIA AURANTIA, A NEW SPECIES FROM THE DOMINICAN REPUBLIC, GREATER ANTILLES

D. JEAN LODGE[1]
Center for Forest Mycology Research, USDA Forest Service, P.O. Box 1377,
Luquillo, PR 00773-1377, USA. E-mail: djlodge@coqui.net

LEIF RYVARDEN
Department of Botany, P.O. Box 1045,
Blindern, N-0316 Oslo, Norway. E-mail: leif.ryvarden@bio.uio.no'

OMAR PAINO PERDOMO-SANCHEZ
Dirección General de Vida Silvestre y Biodiversidad, Secretaria de Estado de Medio Ambiente y Recursos Naturales,
Santo Domingo, República Dominica.

Abstract: *Antrodia aurantia* Lodge, Ryvarden & Perdomo-Sanchez is described as new. It has bright orange resupinate basidiomes that lack rhizomorphs and has pores that are deep, soft, large, and angular to sinuous; it is associated with a brown rot on *Pinus occidentalis*. A key to all American *Antrodia* and *Diplomitoporus* species is provided.

Keywords: *Antrodia radiculosa, Diplomitoporus*, Polyporaceae, *Pinus*, Hispaniola.

Introduction

Historically, the macrobasidiomycetes of the Dominican Republic on the island of Hispaniola have not been well studied (Ciferri 1929). Although polypores are the best represented group of macrobasidiomycetes in the historical records, Ciferri (1929) listed only 19 species of polypores from the Dominican Republic, including four species cited by Murrill (1915), but excluding synonyms and the dubious records indicated by Murrill and Ciferri. The Basidiomycetes of the Greater Antilles project has greatly increased our knowledge of fungi in the Dominican Republic, as more systematic collecting was conducted in different parts of the country over a period of four years. The mycota of the pine forests at high altitude in the interior part of the island is especially interesting because of its geographically isolated position. The Dominican Republic has the easternmost extent of native pine in the Caribbean,

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[1] The Forest Products Laboratory in Madison is maintained in cooperation with the University of Wisconsin; the lab in Puerto Rico is maintained in cooperation with the USDA Forest Service International Institute of Tropical Forestry. This article was written and prepared by a U.S. Government employee on official time and is therefore in the public domain and not subject to copyright.

Pinus occidentalis Swartz. The majority of pine-inhabiting polypores in this area are more or less identical with those seen in the mainland, with dominance by species such as *Fomitopsis cajanderi* (P. Karst.) Kotl. & Pouzar, *F. pinicola* (Sw.:Fr.) P. Karst., *F. rosea* (Alb. & Schwein.) P. Karst., *Gloeophyllum carbonarium* (Berk. & M.A. Curtis) Ryvarden and *Antrodia heteromorpha* (Fr.) Donk. These are all well-known and widespread brown rot species on various gymnosperms.

Thus, it came as a surprise when a polypore with bright orange, widely effused, resupinate basidiomes and large angular pores was discovered on the lower surface of a brown-rotted pine log. An examination showed it to be dimitic in the thin context, consisting of skeletal hyphae and clamped generative hyphae, but monomitic (only generative hyphae present) in the tube trama. The dimitic context, smooth basidiospores that are unreactive with Melzer's reagent, together with the brown rot clearly indicated that *Antrodia* was the proper genus for this species. It did not match, however, any known American species of *Antrodia* (Gilbertson & Ryvarden 1986), nor did we find a suitable name when other literature was consulted (Bondarzew 1953; Murrill 1915; Nuñez & Ryvarden 2000; Ryvarden & Gilbertson 1993). We finally concluded that it represented a new species, which is described below.

Antrodia aurantia Lodge, Ryvarden & Perdomo-Sanchez s*p. nova* Figs. 1–2

Fructificatio resupinata, aurantia; pori angulati, 1 × 1–4 mm; tubi 7–20 mm longi, systema hypharum dimitica, tubi monomitica, hyphae generatoriae fibulatae, hyphae skeletales hyalinae, parietibus crassis vel subsolidae; basidiosporae ellipsoideae, non-dextrinoideae, 5.5–6.5 × 3–3.5 µm, consocies in cariete brunnea in ligno.

Holotype: Dominican Republic, Cordillera Central, Santiago Prov., La Celestina, 550 m. a. s. l., 25 Nov 1999, on dead trunk of *Pinus occidentalis*, Leg. D.J. Lodge DR-51 (CFMR-DR 1044) in herb. JBSD; isotypes in CFMR and O.

Basidiomes annual, resupinate, effused and separable when dry, soft when fresh, fragile when dry; margin wide to narrow, cream to pale yellow or pale orange, cottony; pore surface deep orange when fresh, fading slightly when dry; pores daedaleoid, sinuous to angular, thin-walled, 1–4 mm wide; tubes 7–20 mm deep, tube walls fragile, thin and wavy, concolorous with pore surface; context conspicuously thin, cottony, fragile and up to 0.5 mm thick, taste slightly astringent and unpleasant.

Hyphal system dimitic; skeletal hyphae hyaline, thick-walled to solid, 3–4 µm in diameter, present only in the context; generative hyphae with clamps, thin-walled, richly to moderately branched, 2.5–5 µm in diameter. Only generative hyphae are present in the tube trama.

Cystidia none.

Basidia four-sterigmate, 20–28 × 4–6 µm, with a basal clamp.

Basidiospores ellipsoid, thin-walled, smooth, hyaline, non-amyloid, 5.5–7 × 3–4 µm.

Substrate. On dead trunks of *Pinus occidentalis*.

Distribution. Known only from montane forest, Dominican Republic.

Remarks. The strong orange color and the large, deep, soft, wavy, and irregular pores (Fig. 1) are good field characteristics for this species. *Antrodia radiculosa* (Peck) Gilbn. & Ryvarden is undoubtedly the closest relative, and it also has a bright

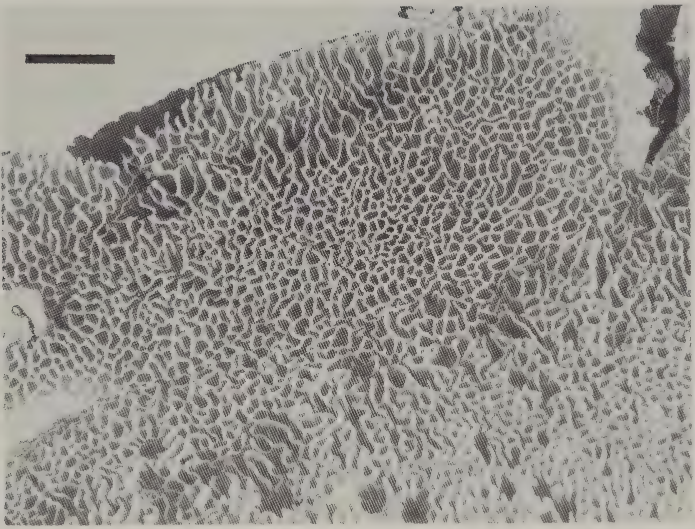

Fig. 1. *Antrodia aurantia* basidiome (holotype). Scale bar = 1 cm.

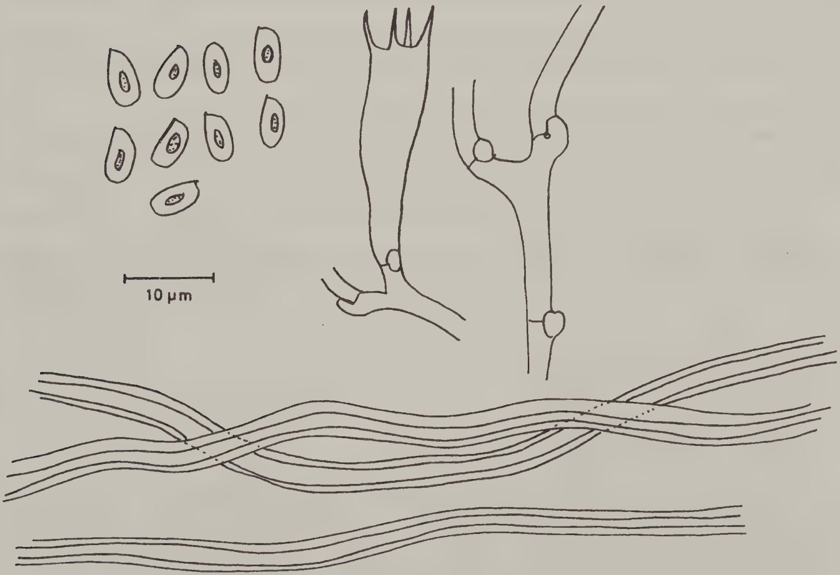

Fig. 2. *Antrodia aurantia* microstructures in 3% KOH (isotype): basidiospores, basidium, and generative hyphae (left to right above); skeletal hyphae from context (below). Scale bar = 10 µm.

orange pore surface. However, as the name implies, it has a wide rhizomorphic margin, and it also differs in having smaller pores (3–4 per mm rather than 1–4 mm diameter). Furthermore, the tube trama is dimitic in *A. radiculosa* rather than monomitic as in *A. aurantia.*

Additional specimens examined. Dominican Republic, Cordillera Central, Santiago Prov., Rincon de Piedra, 850 m a. s. l., 19° 14’ N, 70° 57’ W, 24 Nov. 1999, on hard log (*Pinus occidentalis*) Leg. D.J. Lodge DR-34 (CFMR-DR 1027), CFMR, JBSD and O; Sierra de Baoruco, Perdonales Prov., 1375 m a. s. l., 18° 8’ N, 71° 32’ W, 11 Dec. 1997, Coll. O.P. Perdomo & S. A. Cantrell, Leg. OPP-207 (CFMR-DR 855), CFMR & JBSD.

Key to American species of *Antrodia* (A.) and *Diplomitoporus* (D.)

These two genera share the same microstructure but are separated by the type of rot, the former causing a brown rot and the latter causing a white rot. Both genera are included in the key to aid determination.

1. Spores generally longer than 7 µm 2
1. Spores generally shorter than 7 µm 8

2. Spores slightly fusiform with tapering apex 3
2. Spores cylindrical 4

3. Pores 4–6 per mm; mycelial felts conspicuous in decayed wood; on *Juniperus* .... **A. ferox**
3. Pores 2–3 per mm; mycelial felts not conspicuous, on other genera .... **A. serialis**

4. Causing a heartrot in living *Juniperus*; pores large, daedaleoid .... **A. juniperina**
4. Causing a decay of dead wood or dead branches; pores circular to angular 5

5. Pore surface pale brown 6
5. Pore surface white to cream 7

6. On angiosperms .... **A. malicola**
6. On gymnosperms in spruce–fir ecosystems .... **A. variiformis**

7. Pores 2–3 per mm; on angiosperms and dead branches of *Juniperus* .... **A. albida**
7. Pores 1–2 per mm; commonly on dead gymnosperms, occasionally on angiosperms .... **A. heteromorpha**

8. Spores ellipsoid 9
8. Spores cylindrical to allantoid 14

9. Pore surface yellowish to orange 10
9. Pore surface white to pale sordid brown 11

10. Pores irregular to angular, 1–4 mm wide; margin non-rhizomorphic; trama of generative hyphae only; known only from the Dominican Republic .... **A. aurantia**
10. Pores more or less round to angular, 3–4 per mm; margin strongly rhizomorphic; trama with both generative and skeletal hyphae; widespread in North America .... **A. radiculosa**

11. Basidiomes brittle when dry; pore surface pale sordid brown when dry; tubes as if partly soaked with resin 12
11. Basidiomes hard to soft and cottony when dry; pore surface cream to white 13

12. Spores ellipsoid, 4.5–6 × 2.5 µm ..... **A. gossypina**
12. Spores oval 5.5–7 × 3.5–5 µm ..... **D. overholtsii**

13. Context crumbly to cheesy; rhizomorphs absent; cystidioles usually abundantly present ..... **A. crassa**
13. Context cottony-soft; rhizomorphs usually present; cystidioles absent to rare ..... **A. vaillantii**

14. Spores 2–3 µm wide 15
14. Spores 1–2 µm wide 18

15. Skeletal hyphae strongly amyloid ..... **A. carbonica**
15. Skeletal hyphae non-amyloid 16

16. Spores slightly fusoid; pore surface pale sordid brown when dry; tubes brittle; on angiosperms ..... **A. oleracea**
16. Spores cylindrical - allantoid; pore surface pale cream to straw colored; on gymnosperms 17

17. Spores 5–7 µm long, allantoid; pores 3–4 per mm ..... **D. crustulinus**
17. Spores 4.5–5 µm long, cylindrical; pores 5–7 per mm ..... **A. sitchensis**

18. Pores 1–3 per mm, irregular, sinuous; dissepiments lacerate ..... **A. sinuosa**
18. Pores 3–7 per mm, angular to round; dissepiments entire 19

19. Spores 1.5–2 µm wide 20
19. Spores 1–1.5 µm wide 23

20. On *Juniperus*; tubular, smooth projecting cystidia present ..... **D. rimosus**
20. On other hosts; cystidia absent, but non-projecting pointed cystidiols may occur scattered among the basidia 21

21. Pore surface white with reddish brown spots; a thin brown zone present in the context next to the substrate ..... **A. albobrunnea**
21. Pore surface grayish, cream, pale straw colored; context white without a brown zone next to the substrate 22

22. Pore surface white to greyish; skeletal hyphae partly dissolved in KOH; spores 5–7 µm long ..... **D. lindbladii**
22. Pore surface white to straw colored or sordid brown; skeletal hyphae not dissolved in KOH; spores 4–5 µm long ..... **A. sordida**

23. Pore surface cream to citric yellow when fresh; no strong odor of garlic in fresh condition; species with strongly cracked pore surface belong here 24
23. Pore surface white to pale sordid brown; strong odor of garlic in fresh condition ..... **A. odora**

24. Pores 5-7 per mm; no reaction with KOH ..... **A. xantha**
24. Pores 2-5 per mm; reddish with KOH ..... **A. alpina**

Acknowledgments

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APHYLLOPHORACEOUS FUNGI ON CASTANEA SATIVA IN ITALY

SABINE MAYRHOFER, URSULA PEINTNER
Institute of Microbiology, University of Innsbruck, Technikerstr.
25, 6020 Innsbruck, Austria.

and

ANNAROSA BERNICCHIA
Istituto di Patologia Vegetale, Universita' degli Studi di
Bologna, Via Filippo Re 8, 40126 Bologna, Italy.

Abstract - A total of 328 collections of wood-inhabiting Basidiomycetes were collected on wood of the Sweet Chestnut (*Castanea sativa*) in Italy. The main collecting area was Emilia-Romagna region (North-Central Italy), and in particular the Taro Valley where extensive mixed forests with *C. sativa* predominating still exist. Additional collections come from different Italian regions with patchy spots of chestnut trees. All together, 126 species of Basidiomycetes were identified, which are currently classified in 72 genera. Among the rare species, *Dendrothele dryina*, *Hyphoderma litschaueri*, *Peniophora subpirispora* (so far only known from France), *Scytinostromella heterogenea*, *Sistotrema suballantosporum* and *Xenasma pruinosum* are especially worth mentioning.

Key words: wood-inhabiting Basidiomycetes, white and brown rot fungi.

Introduction

The Sweet Chestnut (*Castanea sativa,* Fagaceae) is the only European species of this genus. The tree was introduced from Asia Minor into Central Europe by the Romans, and since then extensively used for its starch-rich fruits, its wood and the tannic acids. Nowadays, the extension of the Sweet Chestnut reaches from the Mediterranean countries, South Europe to South Eastern Europe. It rarely dominates forest communities, but

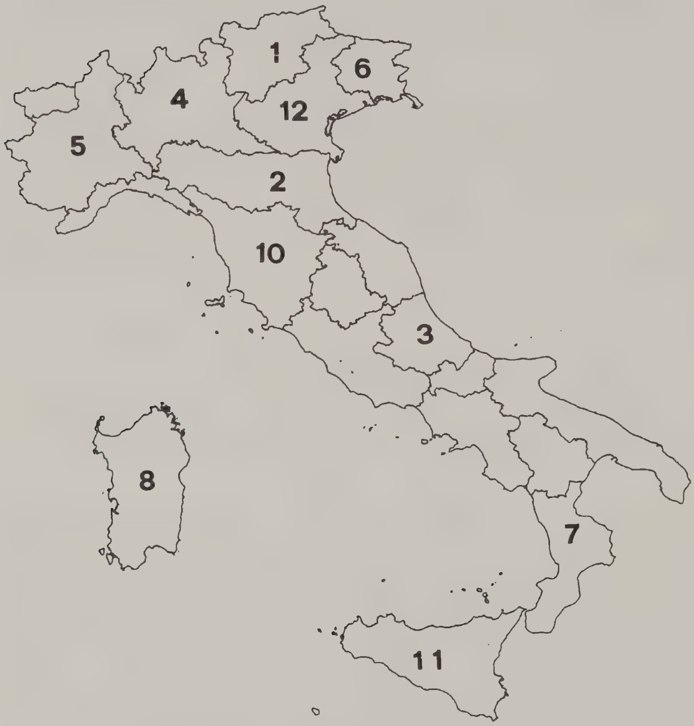

Figure 1: The most important collecting areas. 1) Trentino-Alto Adige, 2) Emilia-Romagna (Taro Valley and other localities), 3) Abruzzo, 4) Lombardy (Fontana Forest and other localities), 5) Piedmont, 6) Friuli, 7) Calabria National Park, 8) Sardinia, 9) Liguria, 10) Tuscany, 11) Sicily, 12) Veneto.

occurs in mixed deciduous forests, usually growing on humid soils in regions with warm and humid summers and mild winters. In the last decades, the Sweet Chestnut was nearly extinct in Central Europe by the fungal parasite *Cryphonectria parasitica,* an ascomycete originally from Easter-Asia, but introduced from North America in 1938. Because of the little importance of *Castanea sativa* for most forest communities, only scattered observations on the fungi related to this tree can be found in the literature Boidin (1994), Eriksson et al. (1973, 1975, 1976, 1978, 1981, 1984), Hansen & Knudsen (1997), Hjortstam *et al* (1987, 1988), Jülich (1984), Langer (1994), Telleria & Melo (1995), Ryvarden & Gilbertson (1993–1994). With exception of Bresadolas early studies (e.g. Bresadola, 1920) interest and research on aphyllophoraceous wood-inhabiting fungi in Italy, started only recently (Bernicchia *et al.* (1986, 1988, 1995, 1999), Bernicchia (1988, 1990, 1995, 2000), Bernicchia & Corbetta (1982), Bernicchia & Padovan (1988, 1991a, 1991b, 1993), Losi (1997, 1999), Lonati (1997), Mayrhofer (1999). Therefore, the main purpose of this study was to assess the lignicolous basidiomycetes, living on *C. sativà*. The wood, is especially rich in tannic acids, therefore we were interested whether or not species typical for this substrate exist.

Collecting Areas

The main collecting areas (Figure 1) were in Emilia-Romagna region (North-Central Italy):

a) the Taro Valley: here, extensive forests with *C. sativa* predominating still exist. These mixed forests of *C. sativa* with *Quercus cerris*, *Juniperus communis*, *Fraxinus* sp., *Acer campestre* and *Robinia pseudoacacia* are in the area around the town Borgo val di Taro at an altitude of 500-800 m. *C. sativa* was planted in this area in the 19th century, when its fruits were still extensively used as food;

b) Corno alle Scale Park and Monte Sole Park.

Many other collections came from different regions of Italy with patchy spots of chestnut trees.

Materials and Methods

Collections are deposited in the herbaria IB and HUBO. The nomenclature follows Parmasto (1997) for corticoid taxa and Ryvarden & Gilbertson (1993-1994) for poroid taxa. For identification, standard literature Jülich (1972-1984), Eriksson, Ryvarden *et al.* (1973-1988), Langer (1994), Ryvarden & Gilbertson (1993-1994) as well as special literature (Boidin (1994, 1997), Koljalg (1995), Hallenberg (1980)) were used. Colours are described comparing them with the Cailleux (1981) colour code. In the list of species, for each species the numbers of collections from a collecting area is given in brackets after the number of the locality. The collecting period is 1981 to 2000, but most of the specimens where collected between 1994 and 1999.

Aleurodiscus disciformis (DC.) Pat., 4 (1), common on *Quercus*.

Amphinema byssoides (Pers.) J. Erikss., 1 (3), 2 (2), 10 (1), common and widespread on coniferous and deciduous wood.

Antrodia gossypia (Speg.) Ryvarden, 2 (1), not common in Italy but widespread in some forests e.g of Sicily, but usually growing on conifers. *A. gossypia* differs from *Antrodiella romellii* (Donk) Niemelä by the softer consistency, larger pores and by causing a brown rot.

Antrodia serialis (Fr.) Donk, 9 (1).

Antrodiella romellii (Donk) Niemelä, 2 (3), common on deciduous wood.

Athelia acrospora Jülich, 2 (1), 8 (1).

Athelia bombacina Pers., 1 (1), a rare species probably collected for the fist time in Italy. *A. bombacina* differs from other *Athelia* spp. by having clamp connections at all septa.

Athelia decipiens (Höhn. & Litsch.) J. Erikss., 2 (9), common and widespread species on both coniferous and deciduous wood.

Athelia epiphylla Pers. s. l. including *A. alnicola* (Bourdot & Galzin) Jülich and *A. salicum* Pers., 2 (2), widespread on deciduous and coniferous wood, ferns and other fungi.

Athelia teutoburgensis (Brinkmann) Jülich, 2 (1), on deciduous and coniferous wood.

Basidioradulum radula (Fr.) Donk, 2 (3), widespread on deciduous wood.

Bjerkandera adusta (Willd.) P. Karst., 1 (1), 5 (1), widespread on deciduous wood.

Botryobasidium laeve (J. Erikss.) Parmasto, 2 (7), common, usually growing on deciduous wood.

Botryobasidium subcoronatum (Höhn. & Litsch.) Donk, 2 (5), common on deciduous and coniferous wood.

Brevicellicium olivascens (Bres.) K.H. Larss. & Hjortstam, 2 (1), uncommon species.

Byssocorticium atrovirens (Fr.) Bondartsev & Singer, 1 (1), 2 (2), widespread but not common. The closely related taxa *B. pulchrum* (Lundell) M.P. Christ. or *B. efibulatum* Hjortstam & Ryvarden differ by having larger spores or lacking clamp connections.

Byssomerulius albostramineus (Torrend) Hjortstam, 6 (1) on stump; a rare species in Italy with only few findings.

Byssomerulius corium (Fr.) Parmasto, 2 (2), 7 (1), 12 (1).

Ceraceomyces tessulatus (Cooke) Jülich, 2 (1), widespread on deciduous and coniferous wood.

Ceriporia reticulata (Hoffm.) Domañski, 2 (3).

Ceriporiopsis gilvescens (Bres.) Domañski, 2 (1), widespread on deciduous wood.

Ceriporiopsis mucida (Pers.) Gilb. & Ryvarden, 2 (1).

Chondrostereum purpureum (Pers.) Pouzar, 2 (1), widespread on deciduous wood.

Coniophora arida var. *suffocata* (Peck) Ginns, 1 (2), mostly on conifers. The variety *suffocata* differs from typical *C. arida* by incrusted basal hyphae.

Coniophora olivacea (Fr.) P. Karst., 2 (1), usually growing on deciduous wood.

Coniophora puteana (Schumach.) P. Karst., 2 (1), on lying log.

Cristinia helvetica (Pers.) Parmasto, 1 (2), 2 (12), uncommon species but widespread in some forests.

Cylindrobasidium laeve (Pers.) Chamuris, 2 (1), common species.

Dacrymyces stillatus Nees: Fr., 10 (1).

Daedalea quercina (L.) Pers., 2 (2), 6 (1), 10 (1).

Daedaleopsis confragosa (Bolt.) J. Schröt., 4 (1).

Daedaleopsis tricolor (Pers.) Bondartsev & Singer, 4 (1), 6 (1).

Dendrothele dryina (Pers.) P.A. Lemke, 2 (1) on living tree. This is are species in Europe, with only three records in Italy.

Dichomitus campestris (Quél.) Domañski & Orlicz, 2 (1).

*Fistulina hepatica (*Schaeff.) Sibth., 2 (6), 10 (4), 8 (2), common on old *Castanea* and *Quercus*.

Fomitopsis spraguei (Berk. & M.A. Curtis) Gilb. & Ryvarden, 2 (1), on burnt trunk. A very rare species, collected only twice in Italy.

Galzinia incrustans (Höhn. & Litsch.) Parmasto, 8 (1) on a small branch lying on the ground. It is a rare species in Italy.

Ganoderma lucidum (W. Curtis) P. Karst., 2 (2).

Gloeocystidiellum luridum (Bres.) Boidin, 2 (1), 8 (1).

Gloeocystidiellum porosum (Berk. & M.A. Curtis) Donk, 2 (8).

Grifola frondosa (Dicks.) Gray, 2 (2), 8 (1), 12 (1).

Hapalopilus croceus (Pers.) Bondartsev & Singer, 9 (1), inside a cavity of an old tree (leg. F. Padovan). It is a very rare species, collected only a few times in Italy.

Henningsomyces candidus (Pers.) Kuntze, 2 (1), on a very small branch.

Hymenochaete rubiginosa (Dicks.) Lév., 1 (1), 2 (3), 3 (1), 8 (2), common on *Quercus* and *Castanea*.

Hyphoderma cremeoalbum (Höhn. & Litsch.) Jülich, 2 (2).

Hyphoderma litschaueri (Burt) J. Erikss. & Å. Strid, 2 (1). This is a rare taxon being so far known from Eastern Europe and North America only. *H. litschaueri* is characterized by a smooth hymenium and moniliform cystidia (50-67 x 5–5.5 µm).

Hyphoderma medioburiense (Burt) Donk, 8 (1), uncommon species.

Hyphoderma mutatum (Peck) Donk, 2 (1), common species. The present collection differs from typical *H. mutatum* by slightly smaller spores.

Hyphoderma praetermissum (P. Karst.) J. Erikss. & Å. Strid, 1 (1), 2 (9), 3 (3), 8 (2), very common species both growing on conifers and deciduous wood.

Hyphoderma puberum (Fr.) Wallr., 3 (3), common species in Italy.

Hyphoderma roseocremeum (Bres.) Donk, 2 (1).

Hyphodontia aspera (Fr.) J. Erikss., 2 (2), 3 (1), common in Italy, but usually found on coniferous wood.

Hyphodontia cineracea (Bourdot & Galzin) J. Erikss. & Hjortstam, 2 (4), uncommon species.

Hyphodontia nespori (Bres.) J. Erikss. & Hjortstam, 2 (7).

Hyphodontia pallidula (Bres.) J. Erikss., 2 (2). This widespread taxon usually grows on conifers.

Hyphodontia quercina (Pers.) J. Erikss., 2 (5).

Hyphodontia sambuci (Pers.) J. Erikss., 2 (1), 8 (2).

Hypochnicium erikssonii Hallenb. & Hjortstam, 2 (1).

Hypochnicium punctulatum (Cooke) J. Erikss., 2 (1).

Jaapia ochroleuca (Bres.) Nannf. & J. Erikss., 2 (1). Typical for this rare species are the hyaline, thick-walled, dextrinoid spores with several oil drops.

Junghuhnia nitida (Pers.) Ryvarden, 2 (4), widespread on deciduous wood.

Junghuhnia separabilima (Pouzar) Ryvarden, 2 (6), rare species in Italy, growing on deciduous wood.

Kavinia alboviridis (Morgan) Gilb. & Budington, 1 (1), this uncommon species is characterized by an olivaceous, hydnoid hymenium and warty spores.

Laetiporus sulphureus (Bull.) Murrill, 2 (3), 10 (4), on old trunks of living *Castanea*.

Lenzites betulinus (L.) Fr., 12 (1), on stump.

Oligoporus subcaesius (A. David) Ryvarden & Gilb., 11 (2).

Oligoporus tephroleucus (Fr.) Gilb. & Ryvarden, 2 (3), 11 (1).

Peniophora laeta (Fr.) Donk, 2 (2).

Peniophora meridionalis Boidin, 8 (2), a typical Mediterranean species.

Peniophora pseudoversicolor Boidin, 2 (1), leg./det. M. Tortic during the eighth Congress of European Mycologists, Bologna 23-29.09.1981, uncommon species.

Peniophora quercina (Pers.) Cooke, 2 (6).

Peniophora subpirispora Boidin & Cavet, 2 (5). This species was described from France growing on wood of *Acer, Prunus* and *Crataegus*. The present collection has slightly smaller spores than typical material.

Phanerochaete calotricha (P. Karst.) J. Erikss. & Ryvarden, 2 (3), a rare species.

Phanerochaete ericina (Bourdot) J. Erikss. & Ryvarden, 2 (1), uncommon species. The spores of our collection are slightly different from typical *P. ericina*.

Phanerochaete magnoliae (Berk. & M.A. Curtis) Burds., 2 (1), rare species, characterized by a raduloid to hydnoid hymenium and thick-walled basal hyphae.

Phanerochaete ravenelii (Cooke) Burds., 2 (2), 3 (1), 11 (1), widespread especially in the Mediterranean area.

Phanerochaete sordida (P. Karst.) J. Erikss. & Ryvarden, 2 (8).

Phanerochaete tuberculata (P. Karst.) Parmasto, 2 (3), 1 (1).

Phanerochaete velutina (DC.) P. Karst., 2 (23), 1 (3), 3 (6), widespread species.

Phellinus ferruginosus (Schrad.) Bourdot & Galzin, 2 (1). Pores size and cystidia are typical, but the spores of the present collection deviate from typical ones, by being thinner than usual.

Phellinus igniarius (L.) Quél., 8 (1).

Phellinus torulosus (Pers.) Bourdot & Galzin, 2 (4), 10 (1).

Phanerochaete pallidovirens (Bourdot & Galzin) Hjortstam, uncommon species.

Phlebiella sulphurea (Pers.) Ginns & Lefebvre, 1 (4), 2 (2).

Physisporinus vitreus (Pers.) P. Karst., 2 (1).

Piloderma bicolor (Peck) Jülich, 2 (2).

Piloderma byssinum (P. Karst.) Jülich, 2 (2)., usually growing on conifers.

Polyporus brumalis Pers., 8 (1).

Polyporus meridionalis (A. David) H. Jahn, 8 (1).

Porostereum spadiceum (Pers.) Hjortstam & Ryvarden, 2 (1).

Pseudotomentella tristis (P. Karst.) M.J. Larsen, 2 (1), uncommon species.

Pulcherricium coeruleum (Lam.) Parmasto, 2 (4).

Radulomyces molaris (Chaillet) M.P. Christ., 1 (1).

Resinicium furfuraceum (Bres.) Parmasto, 2 (1).

Schizopora paradoxa (Schrad.) Donk, 2 (3), 8 (2).

Scopuloides rimosa (Cooke) Jülich, 2 (5), 3 (1).

Scytinostromella heterogenea (Bourdot & Galzin) Parmasto, 1 (1), uncommon species.

Sebacina epigea (Berk. & Broome.) Neuhoff, 2 (1).

Sistotrema brinkmannii (Bres.) J. Erikss., 2 (1).

Sistotrema coroniferum (Höhn. & Litsch.) Donk, 1 (1), 2 (1).

Sistotrema hirschii (Donk) Donk, 2 (2), uncommon species.

Sistotrema oblongisporum M.P. Christ. & Hauerslev, 2 (6).

Sistotrema suballantosporum Hallenb., 2 (2). This is a very rare species, reported only few times from Italy.

Sistotremastrum niveocremeum (Höhn. & Litsch.) J. Erikss., 2 (2).

Skeletocutis nivea (Jungh.) Jean Keller, 2 (2).

Steccherinum ochraceum (Pers.) Gray, 2 (2).

Steccherinum oreophilum Lindsey & Gilb., 2 (2), very rare species.

Stereum hirsutum (Willd.) Gray, 2 (5).

Tomentella bryophila (Pers.) M.J. Larsen, 2 (2), 3 (2).

Tomentella cinerascens (P. Karst.) Höhn. & Litsch., 2 (2), common species.

Tomentella radiosa (P. Karst.) Rick, 1 (2), 2 (2). The spores ofour collections are slightly smaller than normal for the species.

Tomentella stuposa (Link) Stalpers, 1 (1).

Tomentella umbrinospora M. J. Larsen, 2 (2), not common in

Italy.

Tomentellopsis echinospora (Ellis) Hjortstam, 1 (1), 2 (3).

Tomentellopsis zygodesmoides (Ellis) Hjortstam, 2 (1).

Trametes versicolor (L.) Pilát, 2 (2), 10 (1).

Trechispora cohaerens (Schwein.) Jülich & Stalpers, 2 (2).

Trechispora farinacea (Pers.) Liberta, 1 (2), 2 (6).

Tubulicrinis sororius (Bourdot & Galzin) Oberw., 2 (2).

Tulasnella calospora (Boud.) Juel, 2 (2).

Tulasnella violacea (Johan - Olsen) Juel, 2 (1).

Tulasnella violea (Quél.) Bourdot & Galzin, 2 (2), 8 (1).

Vesiculomyces citrinus (Pers.) E. Hagstr., 2 (1).

Vuilleminia comedens (Nees) Maire, 2 (2), 8(2).

Xenasma pruinosum (Pat.) Donk, 1 (1), 2 (2)1 (1), 2 (2), rare species.

Conclusions

All together, 125 species of Basidiomycetes currently classified in 72 genera were identified on *Castanea sativa*. 95 species are corticoid and belong to Corticiaceae s.l. while 31 species are poroid and currently classified in different families (Hansen & Knudsen, 1997).

More than 300 collections were found in the Emilia-Romagna because of the extensive mixed forests with abundant *C. sativa*. Thus, it is not surprising that also the highest species diversity was observed in this region, with 60 % of the species being found only in this collecting area. The reason may be the extensively sampling, but might also reflect the higher species diversity of lignicolous species in *C. sativa* stands compared to scattered trees. In the Emilia-Romagna, the most abundant species were *Hymenochaete rubiginosa, Vuilleminia comedens* and *Stereum hirsutum* during our most extensive sampling period in October 1998. Other dominant species on C. *sativa* in the Emilia-Romagna were determined by the number of their collections (n): *Phanerochaete velutina* (n = 32), *Hyphoderma praetermissum* (n = 15), *Cristinia helvetica* (n = 14), *Fistulina hepatica* (n= 12), *Athelia decipiens* (n = 9), *Gloeocystidiellum* *porosum* and *Phanerochaete sordida* (n = 8), *Trechispora farinacea*, *Laetiporus sulphureus* and *Botryobasidium laeve* (n = 7).

Few reports about saprophytic fungi on *Castanea sativa* exist. Our study shows that most of the frequent and dominant species on C. *sativa* have a broad substrate spectrum and are common and widespread in Europe. No species exclusively adapted to the wood of *C. sativa* was found, but interestingly, the tree is colonized also by taxa, which normally are growing almost exclusively on coniferous wood like *Antrodia gossypia* and *Tubulicrinis sororius.*

Most of the identified taxa are causing a white rot (91 %), with the exceptions of *Antrodia gossypia*, *A. serialis, Coniophora* spp., *Daedalea quercina, Fistulina hepatica, Fomitopsis spraguei, Laetiporus sulphureus, Oligoporus tephroleucus, O. subcaesius, Jaapia ochroleuca,* which cause a brown rot (8,8 %). Some of the reported basidiomycetes are not purely saprophytic on wood, but are known to form ectomycorrhizae such as *Tomentella*, *Piloderma bicolor*, *Amphinema byssoides* and *Byssocorticium* spp. (Koljalg et al., 2001).

Among the rare species, *Dendrothele dryina*, *Hyphoderma litschaueri*, *Junghuhnia separabilima*, *Peniophora subpirispora*, *Scytinostromella heterogenea*, *Sistotrema suballantosporum* and *Xenasma pruinosum* are especially worthwhile mentioning.

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AMANITA PALLIDOCARNEA, A SPECIES OF AMANITA SECTION VAGINATAE WITH PINK LAMELLAE FROM SOUTHEAST ASIA [1]

ZHU-LIANG YANG
Kunming Institute of Botany, Academia Sinica, Kunming 650204, China
E-mail address: zlyang@public.km.yn.cn

Abstract: A lectotype for *Amanita pallidocarnea*, which has pink lamellae, and was originally described from Indonesia, is designated. Based on a study of the lectotype, and additional collections made from southern China, the species is redescribed and illustrated.

Key words: lectotype designation, systematics, Amanitaceae

In 1914 Höhnel published a taxon under the name of *Amanitopsis vaginata* var. *pallidocarnea* based on material collected from Indonesia, although no citation of voucher specimen(s) was made. Boedijn (1951) furnished a description of it, raised this variety to species rank, and made a new combination, namely *Amanita pallidocarnea* (Höhn.) Boedijn. However, morphological and anatomical information on the species is still imperfect. During my visit to Harvard University Herbaria, I found a sole collection labeled as "*Amanitopsis vaginata* var. *pallidocarnea* v. H." with handwriting of F. von Höhnel in the von Höhnel herbarium housed in Farlow Herbarium. It is probably the only voucher specimen based on which the name was proposed and, thus, is designated here as the lectotype for the taxon. Based on a study of the lectotype, and additional collections made from southern China, this species is redescribed and illustrated herewith.

Methodology and notation follow those of Yang (1997). Color names with first letters capitalized, e.g. "Fuscous" are from Ridgway (1912). Color codes of the form e.g. "5E4" are from Kornerup & Wanscher (1981); Collections made in China are deposited in the Herbarium of Cryptogams, Kunming Institute of Botany, Chinese Academy of Sciences (HKAS). Farlow Herbarium (FH) numbers represent herbarium sheet numbers. Several specimens of different taxa are arranged on the same sheet.

Amanita pallidocarnea (Höhn.) Boedijn, Sydowia **5:** 319 (1951)
——*Amanitopsis vaginata* var. *pallidocarnea* Höhn., Akad. Wiss. Wien. Sitzungsber., Math.-Naturwiss. Kl., Abt. I, **123:** 74 (1914).

Basidiocarp (figs. 1–2) small to medium-sized. **Pileus** 4–6 cm in diameter, convex to applanate, slightly umbonate, dark grey to dark brown over disc

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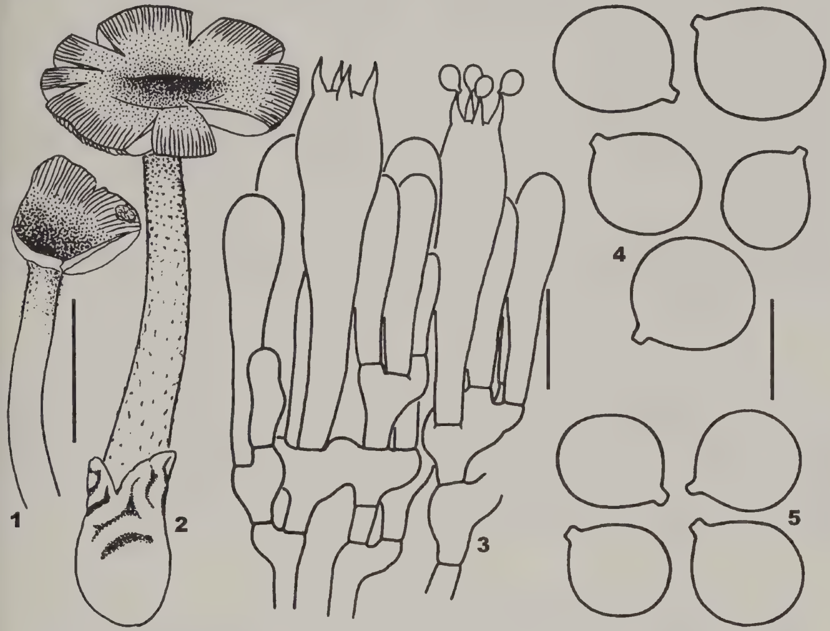
[Fuscous to Fuscous-Black to Benzo Brown; 5E4, 6E4], becoming grey to greyish brown [Hair Brown to Drab to Cinnamon-Drab; 6D3, 6D4] outwards, glabrous or sometimes covered with a few small, felty to submembranous, dirty white volval remnants; margin striate (0.3–0.5R), non-appendiculate; trama white. **Lamellae** free, pink [Flesh Pink; 8A2, 8A3, 9A2, 9A3], crowded, up to 5 mm in height; lamellulae truncate to subtruncate, in 1–2(–3) ranks, evenly distributed. **Stipe** 6–10 × 0.5–1.5 cm, subcylindric or slightly tapering upwards, with apex slightly expanded, exannulate, pinkish, covered with fine, pink [Flesh-Pink to Orient Pink; 9A2, 8A2] squamules, becoming fibrillose and paler downwards, with apex farinose, pinkish to pink; context whitish, fistulose. Basal bulb absent. Volva saccate, thin, membranous, 2–4 × 1.5–2.5 cm, with both surfaces dirty white. **Color of spore print** not known.

Lamellar trama poorly rehydrating in the specimens studied. **Subhymenium** (fig. 3) 30–40(–50) µm thick, with 2–3 layers of subglobose to ovoid or doliform, inflated cells, 12–20 × 10–15 µm, mixed with hardly inflated hyphal segments, 4–7 µm wide. **Basidia** (fig. 3) 40–70(–80) × 12–18 µm, clavate, 4-spored; sterigmata 4–6 µm long; basal septa without clamps. **Basidiospores (**figs. 4–5**)** [75/3/2] (8.5–)9.0–12.0(–14.5) × 8.0–11.0(–14.0) µm [Q = 1.0–1.16(–1.25), **Q** = 1.08 ± 0.05], globose to subglobose, rarely broadly ellipsoid, inamyloid, colorless, hyaline, thin-walled, smooth; apiculus small. **Lamellar edge** a sterile, somewhat gelatinized strip, up to 200 µm wide in side view, composed of very abundant filamentous hyphae, 3–7 µm wide, colorless hyaline or with yellowish contents, running ± parallel to the lamellar edge, mixed with abundant inflated cells, ovoid to subglobose (30–50 × 25–40 µm) to broadly ellipsoid (35–60 × 20–35 µm) or broadly clavate (40–55 × 20–25 µm), thin-walled, colorless hyaline or sometimes with yellowish contents, single and terminal or in chains of 2–3; vascular hyphae rare. **Pileipellis** 50–80 µm thick; upper layer (20–30 µm thick) strongly gelatinized, composed of ± radially arranged, filamentous hyphae 2–4 µm wide, thin-walled, subhyaline or sometimes with brownish vacuolar pigments; lower layer (30–50 µm thick) composed of subradially and compactly arranged, filamentous hyphae 5–12 µm wide, with brownish to brown, vacuolar pigments; vascular hyphae rare, 3–10 µm wide. **Volval limb** on stipe base composed of abundant to very abundant filamentous hyphae, 3–7 µm wide, colorless hyaline, thin-walled, branching and interwoven, sometimes anastomosing; inflated cells fairly abundant to abundant, subglobose to ovoid (30–70 × 25–60 µm) or ellipsoid (50–80 × 20–50 µm), colorless hyaline or occasionally with brownish to yellowish contents, thin-walled, single and terminal, sometimes in chains of 2–3; vascular hyphae rare to scattered to locally conspicuous, 2–6 µm wide. Outer surface of the volval limb similar to the interior, but with more abundant filamentous hyphae; inner surface of the limb strongly gelatinized, composed of filamentous hyphae 2–5 µm wide. Volval remnants on pileus composed of (very) abundant filamentous hyphae 2–8 µm wide, colorless hyaline, thin-walled, frequently branching, interwoven; inflated cells fairly abundant to abundant, subglobose to ovoid (60–

100 × 50–80 µm), sometimes ellipsoid (65–100 × 20–50 µm) or sphaeropedunculate (60–70 × 40–5 µm), usually single and terminal, colorless hyaline, thin-walled; vascular hyphae rare, 3–12 µm wide; outer surface of volval remnant usually with more abundant filamentous hyphae than in interior. **Stipe trama** composed primarily of longitudinally arranged, long clavate, terminal cells, 180–280 × 25–45 µm; filamentous hyphae 2–8 µm wide, scattered in interior, fairly abundant on stipe surface; vascular hyphae rare, 3–20 µm wide.



Figs. 1–5: *Amanita pallidocarnea*. 1. Basidiocarp with a volval remnant on the pileal margin (FH 4712-lectotype); 2. Basidiocarp (HKAS 36701, after photos); 3. Basidia and subhymenium (HKAS 34571); 4. Basidiospores (lectotype); 5. Basidiospores (HKAS 34571). Scale bar = 3 cm for basidiocarps, 20 µm for hymenium and subhymenium, and 10 µm for basidiospores.

Specimens examined: INDONESIA: Tjibodas, 1908, F. von Höhnel *s.n.* (Herb. Höhnel, FH 4712, labeled as "*Amanitopsis vaginata* var. *pallidocarnea* v. H.", lectotype, designated here). CHINA: Hainan Province: Ledong County, Jianfengling, alt. 800 m, 20. VIII. 1999, M. S. Yuan 4373 (HKAS 34571); Changjiang County, Bawangling, 27. VI. 1995, X. L. Wu *s.n.* (HKAS 36701, only two colored photos, no material preserved).

Habitat and Distribution: On the ground in broad-leaved forests. Known from Indonesia; new for China.

Observations: Unfortunately, the lectotype of *A. pallidocarnea* comprises only an imperfect fruitbody, i.e. about a quarter of the pileus connecting with the upper part of the stipe; the lower part of the stipe, and the volva on the stipe base are not preserved. A felty to submembranous, dirty white, volval remnant was found on the pileus (fig. 1). Spores of the lectotype (fig. 4) are [30/1/1] (9.0–)9.5–12.5(–14.5) × 8.5–11.5(–14.0) µm [Q = 1. 0–1.12(–1.15), **Q** = 1.07 ± 0.04].

Due to its fruitbody with pink lamellae, and a saccate volva on the stipe base, features shared with the genus *Volvariella*, *A. pallidocarnea* was suspected of not being a member of the genus *Amanita* (Yang 1997: 102). Having studied the lectotype, and additional material, I found that it is an amanita, and is characterized by its dark colored pileus with relative long striations along the pileal margin, its pink lamellae, pinkish stipe, globose to subglobose spores, and volval remnants with fairly abundant to abundant inflated cells. *Amanita vaginata* var. *roseilamellata* Bresinsky, which was originally described from Germany, also has pinkish lamellae (Bresinsky & Einhellinger, 1987), but differs from *A. pallidocarnea* by its paler pileus, white to greyish stipe, and narrower spores. Furthermore, judging from the description and illustrations provided by Bresinsky & Einhellinger (1987), *A. vaginata* var. *roseilamellata* might have shorter striations along the pileal margin and a more strongly constructed volva with fewer inflated cells.

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MYCOTAXON

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STUDIES IN LEPIOTA III.
Some species from California, U.S.A.

Else C. Vellinga

University of California at Berkeley, 111 Koshland Hall # 3102, Berkeley CA 94720-3102, U.S.A. / National Herbarium, P.O. Box 9514, 2300 RA Leiden, the Netherlands
Email vellinga@uclink4.berkeley.edu; vellinga@nhn.leidenuniv.nl

Lepiota magnispora shows morphological and molecular variation: three groups can be distinguished, each with its own distribution area. A closely related taxon, *Lepiota spheniscispora* spec. nov., is described from central coastal California. It differs morphologically from *L. magnispora* in the overall yellow-brown colours of the pileus, lacking a contrasting dark brown centre. A sister taxon of *L. cystophoroides* is described, viz. *L. scaberula* spec. nov., characterized by a scurfy pileus surface, non-dextrinoid and metachromatic spores, and inconspicuous cheilocystidia.

Key words – Geographical variation, ITS-sequences, *Lepiota magnispora*, cryptic species

INTRODUCTION

The variation in ITS-sequences within the species *Lepiota magnispora* Murrill was investigated as part of a project researching the phylogenetic relationships of the tribus Lepioteae Fayod and Leucocoprineae Singer within the family Agaricaceae (Fr.) Chevall. as recognized and defined by Singer (1986). The discovery of new species is a spin-off of this project, and two Californian taxa are described here.

MATERIAL AND METHODS

Morphology – Colour annotations in the macroscopical descriptions are from Munsell Soil Color Charts (1975). The notation [57,4,3] indicates that measurements were made on 57 spores in four samples in three collections. DAPI (4',6-diamidino-2phenylindole), 1 μg/ml, was used to visualize the nuclei in the spores. The following abbreviations are used: avl for average length, avw for average width, Q for quotient of length and width and avQ for average quotient. A list of all collections studied is given in the Appendix.
Molecular identification – DNA was extracted from fresh and herbarium material and the internal transcribed spacer (ITS) of the nuclear ribosomal repeat was amplified by the polymerase chain reaction (PCR) with the fungal specific primers ITS1F and ITS4 (Gardes & Bruns, 1993). Sequencing of both strands was performed with an ABI model

377 sequencer (Applied Biosystems, Foster City, CA, U.S.A.) using a Thermo Sequenase™ Dye terminator Cycle Sequencing Pre-Mix Kit (Amersham Pharmacia Biotech, Piscataway, NJ, U.S.A.), with primers ITS1 or ITS5, ITS2, ITS3, and ITS4. The raw data were processed with the use of DNA Sequencing Analysis v.2.1.2 and Sequence Navigator v.1.0.1 (also Applied Biosystems). The sequences thus obtained were aligned in ClustalW (online http://www.ch.embnet.org/software/ClustalW.html), with the following settings: opening gap penalty10, end gap penalty 10, extending gap and separation gap penalty both 0.05. Sequences were analysed using PAUP 4.0b5 (Swofford, 2001). Sequences have been deposited in Genbank, and the accession numbers are given in the Appendix.

DESCRIPTIVE PART

1. Lepiota magnispora and L. spheniscispora

Lepiota magnispora (syn. *L. ventriosospora* D.A. Reid, see Vellinga, 2000) shows variation in colours of the basidiocarp, spore size, and in ITS-sequences throughout its distribution area. Three different groups can be distinguished on account of the sequence data (Fig. 1). The first group (*L. magnispora* 1) is found throughout the western part of North America, and is characterized by a dark brown central part of the pileus, contrasting with the rest of the surface. A second group (*L. magnispora* 2), occurring mainly in Europe, is known there as *L. ventriosospora* var. *ventriosospora*, including some elements of var. *fulva* Bon. The squamules on the pileus are slightly paler than the pileus centre, the veil on the stipe can be yellow or white, and it occurs in deciduous and coniferous woods. The third group (*L. magnispora* 3) has representatives in Europe and China. It has a distinctly brown pileus, and is known as var. *fulva* (pro parte) and var. *umbrinosquamosa* (Hongo) Bon. and occurs in deciduous woods (information on the ecology of the Chinese collection is lacking, except that it was found at 3600 m asl). *Lepiota fusispora* Kauffman, described from the Adirondack Mountains (New York, U.S.A.) may belong to this group. Bon (1993) mentioned a third variety, viz. var. *umbrinorufescens* Bon, growing in wetter habitats, like Alno-Padion, with *Sphagnum* or in marshy *Salix* habitats. Sequence data on the latter taxon are not available.

The small number of samples and the underrepresentation of many areas in Asia, and the eastern part of North America, do not permit generalizations on distribution patterns nor theories on biogeographic pathways. Further sequencing research on other genes could demonstrate whether the tree inferred from sequence data of the ITS-region actually represents species, in which case *L. magnispora* should be split up into three different species (*L. magnispora*, *L. ventriosospora*, and a third taxon). Infraspecific variation in ITS-sequences is known for other species, like *Flammulina velutipes* (Curtis: Fr.) Singer (Methven et al., 2000), where the different ITS-types are compatible with each other, and are considered to belong to the same, biological, species. This type of data is not available for *Lepiota* species.

Differences in ITS-sequences between European and Californian representatives of the same morphological taxon are common. Two examples that illustrate the range are: 1. *Melanophyllum haematospermum* (Bull.: Fr.) Kreisel from the Netherlands and from *Sequoia sempervirens* (D. Don) Endl. woods in Mendocino Co. (4.1 % difference, 27 bases out of 653); and 2. *Cystolepiota pulverulenta* (Huijsman) Vellinga from the Netherlands and Great Britain versus a collection from stands of *Cupressus macrocarpa* Gordon in San Mateo Co. (2.2 % difference, 15 bases out of 682). The differences in ITS are not associated with macroscopical or microscopical differences, but in both

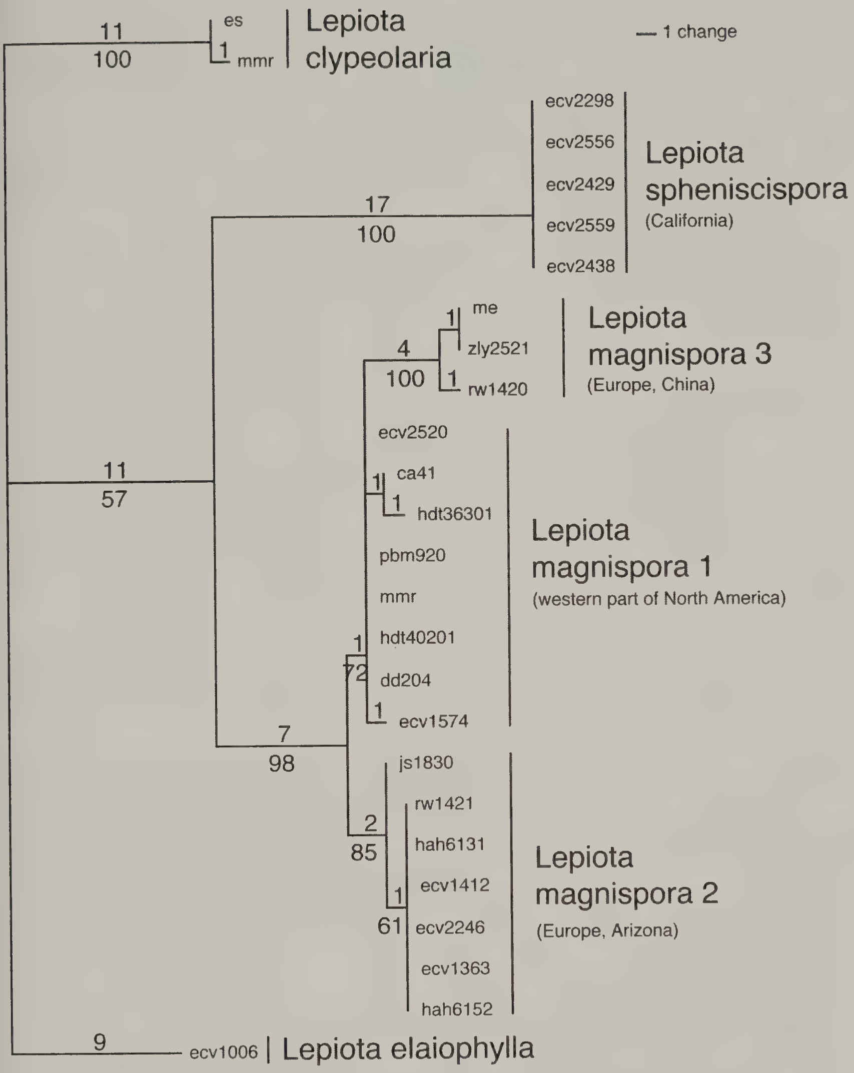
— 1 change
11
100
es
1
mmr
Lepiota clypeolaria
17
100
ecv2298
ecv2556
ecv2429
ecv2559
ecv2438
Lepiota spheniscispora
(California)
4
100
1
me
zly2521
1
rw1420
Lepiota magnispora 3
(Europe, China)
11
57
ecv2520
1
ca41
1
hdt36301
pbm920
mmr
1
hdt40201
72
dd204
1
ecv1574
Lepiota magnispora 1
(western part of North America)
7
98
js1830
rw1421
2
85
hah6131
ecv1412
1
61
ecv2246
ecv1363
hah6152
Lepiota magnispora 2
(Europe, Arizona)
9
ecv1006
Lepiota elaiophylla

Fig. 1. Relationship between *L. clypeolaria, L. spheniscispora,* and *L. magnispora*, with *L. elaiophylla* as outgroup, based on parsimony analysis of the nuclear ribosomal DNA ITS-sequences. Collections are indicated with the collector's initials and collection number, if any. One of 10,000 (maxtrees = 10,000) most parsimonious trees is shown. Bootstrap supports > 50 % are indicated under the branches, based on 1000 replicates. The analysis is based on 48 parsimony-informative characters; tree length = 69, CI = 0.8406, RC = 0.7877.

examples, are much greater than the infraspecific variation encountered in L *magnispora*. On the other hand, some species with a very wide distribution area do not show any differentiation in ITS-sequences. Examples are *Leucoagaricus barssii* (Zeller) Vellinga and *L. leucothites* (Vittad.) Wasser, both known from throughout the Northern and Southern Hemisphere (including Australia). These fungi occur in man-made habitats like lawns and agricultural fields, perhaps suggesting a relatively recent introduction to newly inhabited areas, where these habitats were absent before the arrival of settlers.

Besides the infraspecific variation in *L. magnispora*, a closely related taxon was discovered (Fig. 1), with a limited distribution in the vicinity of San Francisco, California, often growing under *Eucalyptus globulus* Labill. This taxon does not differ in microscopical characters from *L. magnispora*, but can be recognized in the field on account of the yellow-brown colours, and the pileus centre which is only slightly darker than the rest of the pileus. This is in contrast with the western North American variant of *L. magnispora*, which exhibits a distinctly darker umbo than the limb of the pileus. This separate taxon is described here as a new species, *L. spheniscispora* Vellinga.

The possibility that *L. spheniscispora* might be a hybrid between *L. magnispora* and *L. clypeolaria* (Bull.: Fr.) Kumm. was discarded for several reasons. First, the morphological characters, especially the shape of the spores, do not support a close relationship with *L. clypeolaria*. Secondly, *L. clypeolaria* has not been found in the area of California where the new taxon occurs; it has only been found from northern California northward. And thirdly, the ITS-sequences were not heterogeneous, suggesting that the two nuclei had the same ITS-type (compare Hughes & Petersen (2001) for the occurrence of a hybrid in the genus *Flammulina* P. Karst.). The ITS-sequence of *L. spheniscispora* has characters in common with both *L. clypeolaria* and *L. magnispora*, but these characters are not spatially separated (compare the situation in the *Fusarium graminearum* complex (O'Donnell et al., 2000)), and *L. spheniscispora* has unique characters as well.

The habitat, and the limited distribution of the newly discovered species, as far as is known at present, may suggest a recent introduction from Australia, but evidence for this hypothesis is lacking. Aberdeen (1992) mentioned one collection of *L. clypeolaria* from South-Eastern Queensland in Australia, depicting it with spores characteristic of both *L. magnispora* and the new taxon. The macromorphological description does not allow for a species identification. *Lepiota clypeolaria* and its allies are not mentioned in Grgurinovic's treatment of South Australian fungi (1997), nor is there any herbarium material of this species in MEL (Dr Tom W. May, personal communication).

Lepiota spheniscispora Vellinga, sp. nov. — Fig. 2.
Lepiotae magnisporae similissima, sed in spatii interne transcripti sequentia ("ITS"); pileus fulvo-cinnamomeus; sporae 13.0-18.5(-22.5) µm longae 4.5-5.5 µm latae ventricoso-fusiformes.
Holotype 'U.S.A., California, Contra Costa Co., Tilden Regional Park, 26-XI-2000, E.C. Vellinga 2556 (UC)'.
Etymology: The word 'spheniscus' is derived from the Greek 'σφηνος' meaning 'wedge', and is used for a genus of penguins. The spore shape resembles the form of an upright penguin.

Pileus 24-40 mm, when young hemispherical or conico-convex with rounded apex, without umbo, or very widely conical, expanding to applanate with distinct to low,

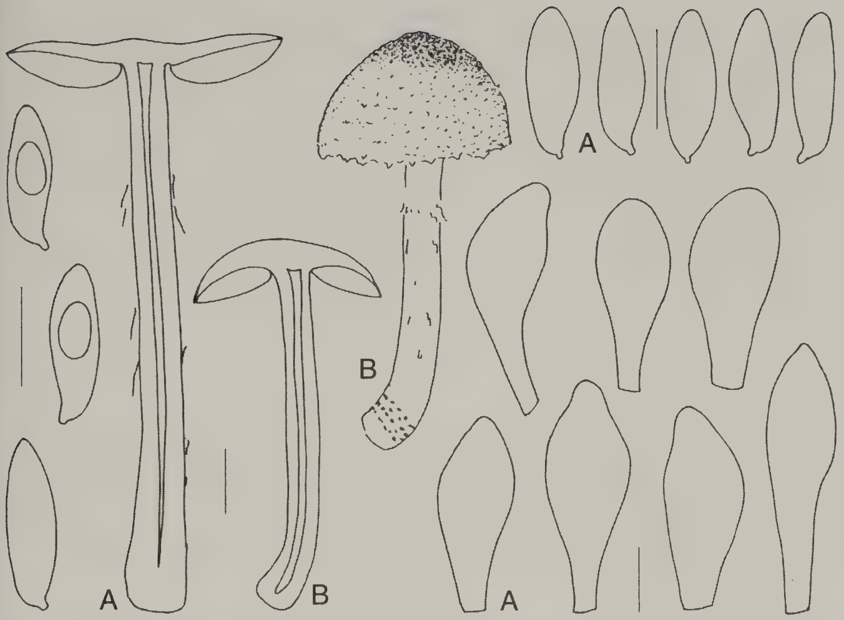

Fig. 2. *Lepiota spheniscispora* – Habitus, spores, and cheilocystidia. A. from holotype; B. from coll. E.C. Vellinga 2559. Scale bar is 1 cm for basidiocarps, 10 µm resp. for microscopic characters.

inconspicuous umbo, orange rusty-brown, or orange-brown in centre (approximately Mu. 7.5 YR 6/6, 5 YR 4/6, K. & W. 6E4 but warmer), around centre slightly paler (approximately 7.5 YR 7/5, 5 YR 5/8 in young specimen), in centre plush-like, not broken up into squamules, around centre breaking up into radially arranged, small plush-like squamules on whitish, radially fibrillose background; margin in younger specimens fringed with white woolly velar remnants, exceeding lamellae. Lamellae, L= 55-75, l = 0-1(-3), moderately crowded to rather distant, free, segmentiform in young specimens, ventricose in older specimens, c. 4-5 mm wide, pale cream to cream with white, eroded to fimbriate-eroded edge. Stipe 25-70 x 6-7 mm, cylindrical to slightly widened at base, often curved in basal part, hollow, in upper part white to cream and innately lengthwise fibrillose, with halfway to one third from apex white fibrillose-lanate annular zone, below that zone with white to yellow, often irregular, lanate floccules, in lower one third with small brown squamules as on pileus, white tomentose at base, with white basal mycelial cords. Context in pileus white and dull, in stipe creamy to white and shiny. Smell strong, astringent, like rubber (as *Lepiota cristata*). Taste not recorded.

Spores [72, 4, 4] 13.0-18.5(-22.5) x 4.5-5.5 µm, avl x avw = 15.1-16.6 x 4.8-5.1 µm, Q = 2.7-3.7(-4.4), avQ = 3.05-3.3, in side-view elongate fusiform, with straight abaxial side and convex adaxial side, with suprahilar depression, in frontal view dextrinoid, not metachromatic in Cresyl Blue, congophilous, and red in Congo Red. Basidia 24-36 x 8.5-11µm, 4-spored, rarely some 2-spored basidia mixed in. Lamella edge sterile; cheilocystidia 17-40 x 8-15 µm, narrowly clavate, rarely clavate, utriform-fusiform, or slightly lageniform, not coloured, and slightly thick-walled. Pleurocystidia absent. Pileus covering made up of erect, 125-270 x 7-11 µm, cylindrical, slightly flexuous elements, rarely 1-septate, with rounded apex, with brown walls. Narrowly clavate basal elements present, but not abundant. Lower connecting hyphae with incrusted brown pigments. Stipitipellis a cutis of non-coloured, cylindrical hyphae, 2.0-4.0 µm wide, in lower part with loosely attached cylindrical, flexuous, often brown hyphae, up to 15 µm in diameter. Clamp-connections present in all tissues.

Habitat & distribution – Solitary to gregarious in small groups, apparently saprotrophic, under *Eucalyptus globulus* and in groves of *Quercus agrifolia* Nee. November-February. Known from three localities in the central coastal area of California.

2. **Lepiota scaberula** Vellinga, spec. nov. – Fig. 3.

Lepiotae cystophoroidi affinis; pileus furfuraceus; sporae 5-7 µm longae 3-4 µm latae; cheilocystidia in basidiocarpis maturis inconspicua anguste clavata.
Holotype 'U.S.A., California, San Mateo Co., San Francisco Watershed, near Pulgas Water Temple, 8-XII-2000, E.C. Vellinga 2595 (UC)'.
Etymology: The word 'scaberula' is derived from the Latin word 'scaber' meaning 'scurfy', referring to the aspect of the pileus surface.

Pileus 12-32 mm, hemispherical-paraboloid when young and still connected to stipe with margin, expanding to convex or plano-convex, with flattened centre or umbo, cream to pale brown at centre, with age yellow-brownish (10 YR to 7.5 YR 6/6), paler

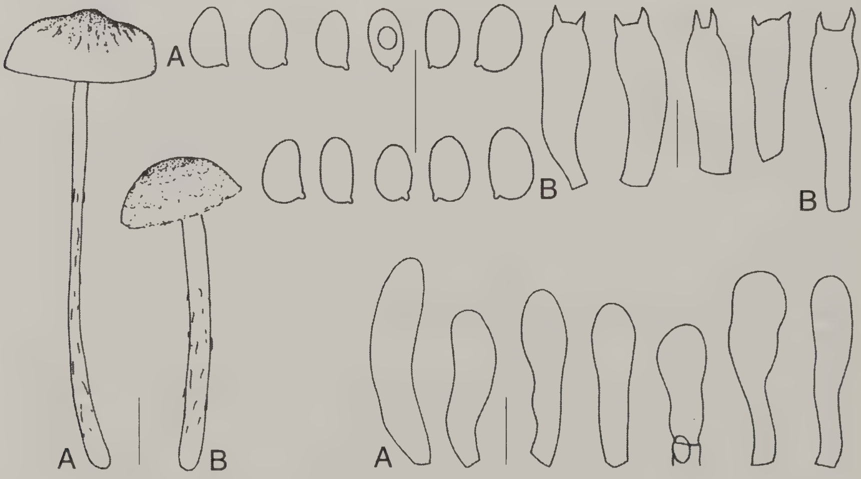

Fig. 3 *Lepiota scaberula* – Habitus, spores, cheilocystidia and basidia. A. from holotype; B. from coll. E.C. Vellinga 2307. Scale bar is 1 cm for basidiocarps, 10 µm for microscopic features.

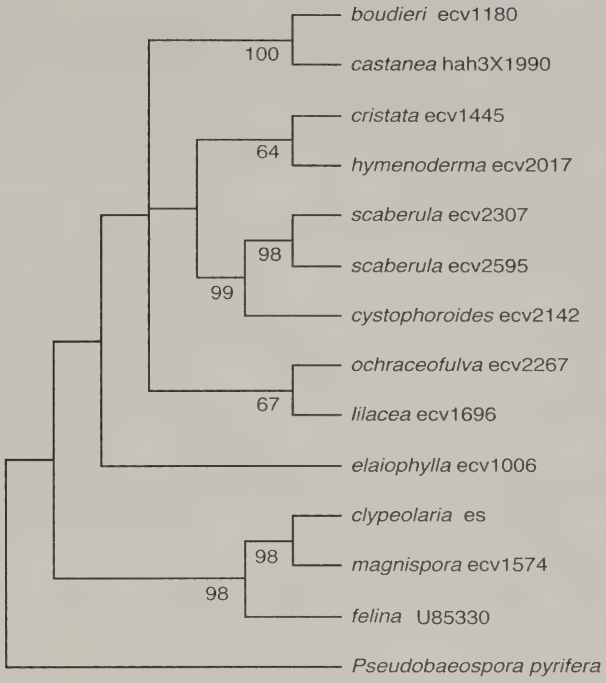
boudieri ecv1180
castanea hah3X1990
100
cristata ecv1445
hymenoderma ecv2017
64
scaberula ecv2307
scaberula ecv2595
98
99
cystophoroides ecv2142
ochraceofulva ecv2267
lilacea ecv1696
67
elaiophylla ecv1006
clypeolaria es
magnispora ecv1574
98
98
felina U85330
Pseudobaeospora pyrifera

Fig. 4. Relationships of *L. scaberula* with other members of *Lepiota* s. str., with *Pseudobaeospora pyrifera* Bas & L. Krieglst. as an outgroup, as inferred from nuclear ribosomal DNA ITS-sequences. Collections are indicated with the collector's initials and collection number, if any, or with a genbank accession number. A strict consensus tree of two most parsimonious trees is shown. Bootstrap supports > 60 % are indicated under the branches, based on 500 replicates. The analysis is based on 207 parsimony informative characters; tree length = 579; CI = 0.5544, RC = 0.2835.

around centre to whitish at margin, at centre glabrous, granulose under lens, around centre irregularly fibrillose-squamulose, squamules often v-shaped, disappearing towards margin; margin exceeding lamellae widely. Lamellae, L = 28-45, l = 1-3,moderately crowded to moderately distant, free, segmentiform when young, later slightly ventricose, up to 3 mm wide, creamy with slightly pinkish sheen when young, later yellowish (10 YR 8/3-4), with white slightly eroded to fimbriate-eroded edge. Stipe 38-50 x 2-4 mm, cylindrical, often a bit flexuous, hollow, pale whitish in upper part, pale reddish in lower part, innately fibrillose, and whitish-woolly in lower part, with mycelial cords at base. Context white and dull in pileus, shiny and white to cream in stipe. Smell of intact basidiocarps like *Lepiota cristata*, of cut basidiocarps farinaceous, like putty, or more rubber-like. Taste not recorded.

Spores [33, 2, 2] 5.0-7.0 x 3.0-4.0 µm, avl x avw = 5.7-6.2 x 3.3-3.6 µm, Q = 1.5-2.2, avQ = 1.70-1.73, ellipsoid to oblong, not congophilous, not dextrinoid and with pink inner wall in Cresyl Blue, binucleate. Basidia 19-23 x 6.0-7.0 µm, 4-spored. Lamella edge sterile, but cheilocystidia difficult to find in mature specimens.

Cheilocystidia 18-28 x 6.5-7.5 µm, cylindrical and slightly widened at apex, in older specimens often difficult to find. Pleurocystidia absent. Hymenophoral trama regular. Pileus covering made up of repent brown coloured hyphae, cylindrical to slightly inflated, 3-15 µm wide, with brown granular or evenly distributed intracellular pigment, with uplifted terminal ends; some non-coloured hyphae with clavate terminal uplifted ends. Stipitipellis a cutis of cylindrical non-coloured hyphae, 1.5-3.0 µm wide, with flexuous, cylindrical, 5.0-10 µm wide velar hyphae covering the pellis in lower half. Clamp-connections present.

Habitat & distribution. – Gregarious, saprotrophic, in *Sequoia sempervirens* forests, and in stands of *Cupressus macrocarpa*. December. Known from two localities in San Mateo Co., California.

Lepiota scaberula is a sister taxon of the European species *L. cystophoroides* Joss. & Riousset, from which it differs by the smaller spores (6.0-8.0(-8.6) x 3.8-4.5 µm in *L. cystophoroides*), the smaller and much less conspicuous cheilocystidia and the slightly different structure of the pileus covering (see Josserand & Riousset (1972) for a full description of *L. cystophoroides*). The pileus covering of *L. cystophoroides* is made up of radial, repent coloured hyphae leading to patches of clavate elements which give rise to chains of globose, loose elements. Spores of both species are non-dextrinoid, have a pink inner wall in Cresyl Blue and two nuclei. This places these species in the vicinity of species with a hymeniform pileus covering such as *L. lilacea* Bres. and *L.cristata* (Bolt.: Fr.) Kumm. (Fig. 4).

It is interesting to note that *L. cystophoroides* occurs in *Cedrus* woods in warm regions of Europe.

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APPENDIX

List of collections examined for this study, with Genbank accession numbers for the ITS-sequences (all starting with AF39). Herbarium abbreviations are according to Holmgren et al. (1990).

Lepiota magnispora 1

Canada, prov. British Columbia, Revelstoke National Park, Inspiration Forest, 4-IX-1989, E.C. Vellinga 1574 (L) AF391016.

U.S.A., California, Humboldt Co., Patrick's Point State Park, Beach Creek Trail, 19-X-1986, D. Deshazer 204 (HSC) AF391009; Mendocino Co., Caspar, 31-XII-1997, P.B. Matheny 920 (WTU) AF391013; Van Damme State Park, 19-XI-2000, E.C. Vellinga 2520 (UC) AF391010; Santa Cruz Co., Santa Cruz, 19-II-2000, M.M. Rogers (UC) AF391012; Siskiyou Co., Mt Shasta, 3-IX-1976, H.D. Thiers 36301 (SFSU) AF391014; Idaho, Valley Co., McCall, 10-IX-1979, H.D. Thiers 40201 (SFSU) AF391015; Oregon, Coos Co., Bandon, Coos County Forest, Oregon Beaver Hill Area, 5-XI-1976, C. Ardrey 41 (HSC) AF391011.

Lepiota magnispora 2

Belgium, Prov. Luxembourg, Melreux/Biron, 15-IX-1998, R. Walleyn 1421 (GENT) AF391018.

France, dépt. Meuse, Beaulieu-en-Argonne, 25-X-1998, H.A. Huijser (herb. Huijser) AF391019.

Luxembourg, Marienthal, 25-IX-1988, E.C. Vellinga 1412 (leg. F. Benjaminsen) (L) AF391020.
The Netherlands, prov. Limburg, Hopel-Kerkrade, mine Laura-Julia, 19-IX-1998, E.C. Vellinga 2246 (L) AF391021; Valkenburg, Schaelsberg, 6-X-1999, H.A. Huijser (herb. Huijser) AF391023.
Switzerland, ct. Ticino, Malvaglia, 12-IX-1988, E.C. Vellinga 1363 (L) AF391022.
U.S.A., Arizona, Cochise Co., Chiricahua Mountains, Onion Pass, 4-IX-1993, J. States 1830 (AEF1015) (MICH) AF391017.

Lepiota magnispora 3
Belgium, Prov. Luxembourg, Melreux/Biron, 15-IX-1998, R. Walleyn 1420 (GENT) AF391007.
China, Yunnan Prov., Yiliang Co., Mugan Township, Sanjiangkon Nature Reserve, 16-IX-1998, Z.L. Yang 2521 (HKAS) AF391006.
Germany, Baden-Württemberg, NE of Riedheim, 2-IX-1994, M. Enderle (L) AF391005.

Lepiota spheniscispora
U.S.A., California, Contra Costa Co., Tilden Regional Park, 18-XII-1999, E.C. Vellinga 2429 AF391002; ibidem, 26-XI-2000, E.C. Vellinga 2556 (holotype) AF391001 and 2559 AF391004; Marin Co., Mount Tamalpais, along Yolanda trail, 15-II-2000, E.C. Vellinga 2438, AF391003; San Mateo Co., San Francisco Watershed, near Pulgas Water Temple, 4-XII-1998, E.C. Vellinga 2298, AF391000 (all in UC).

Lepiota clypeolaria
Germany, locality unknown, 4-IX-1989, E. Schätzle (L) AF390998.
U.S.A., Oregon, Lane Co., Eugene, Mount Pisgah Arboretum, 4-XI-2000, M.M. Rogers (UC) AF390999.

Lepiota elaiophylla
The Netherlands, prov. Noord-Holland, Uithoorn, de Kwakel, in greenhouse, 15-IX-1986, E.J.M. Uljé, (coll. E.C. Vellinga 1006) (L) AF391024.

Melanophyllum haematospermum
The Netherlands, prov. Limburg, Hopel-Kerkrade, mine waste heap Laura-Julia, 19-IX-1998, E.C. Vellinga 2249 (L) AF391038.
U.S.A., California, Mendocino Co., Navarro River Redwoods State Park, 19-XI-2000, E.C. Vellinga 2517 (UC) AF391039.

Cystolepiota pulverulenta
Great Britain, Surrey, Richmond, Kew Botanical Garden, 8-IX-1992, E.C. Vellinga 1872 (L) AF391036.
The Netherlands, prov. Limburg, Cadier en Keer, Savelsbos, 9-X-1991, E. C. Vellinga 1763 (L) AF391037.
U.S.A., California, San Mateo Co., San Francisco Watershed, near Pulgas Water Temple, 8-XII-2000, E.C. Vellinga 2572 (UC) AF391035.

Lepiota scaberula
U.S.A., California, San Mateo Co., Wunderlich County Park, 26-XII-1998, E.C. Vellinga 2307 AF391029; San Francisco Watershed, near Pulgas Water Temple, 8-XII-2000, E.C. Vellinga 2595 (holotype) AF391030 (both in UC).

Lepiota cystophoroides
France, dept l'Hérault, Cêdraie d'Escandorgue, 20-X-1997, E.C. Vellinga 2142 (L) AF391031.

Lepiota boudieri
The Netherlands, prov. Noord-Holland, Amsterdam-Buitenveldert, 17-IX-1987, E.C. Vellinga 1180 (L) AF391025.

Lepiota castanea
The Netherlands, prov. Limburg, Brunssum, mine Hendrik, 3-X-1990, H.A. Huijser (herb. Huijser) AF391026.

Lepiota cristata
Luxembourg, Hollenfels, 28-IX-1988, E.C. Vellinga 1445 (L) AF391027.

Lepiota hymenoderma
The Netherlands, prov. Limburg, Elsloo-Geulle, Bunderbos, 7-IX-1996, E.C. Vellinga 2017 (L) AF391028.

Lepiota ochraceofulva
The Netherlands, prov. Flevoland, Noordoostpolder, Urkerbos, 23-IX-1998, M.M. Nauta (coll. E.C. Vellinga 2267) (L) AF391032.

Lepiota lilacea
The Netherlands, prov. Noord-Holland, Heemstede, 2-X-1990, E.C. Vellinga 1696 (L) AF391033.

Pseudobaeospora pyrifera
Germany, Bavaria, Kitzinger, Klosterforst, 10-IX-1995, L. Krieglsteiner (isotype, REG) AF391034.

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STUDIES IN LEPIOTA IV.
Lepiota cristata and L. castaneidisca

Else C. Vellinga

University of California at Berkeley, 111 Koshland Hall # 3102, Berkeley CA 94720-3102, U.S.A. / National Herbarium, P.O. Box 9514, 2300 RA Leiden, the Netherlands
Email vellinga@uclink4.berkeley.edu; vellinga@nhn.leidenuniv.nl

Lepiota castaneidisca, though generally considered a synonym of *L. cristata*, is rediscovered as a separate species. It is macroscopically, molecularly, and ecologically distinct from *L. cristata*, and within the species two groups can be distinguished on molecular grounds. A third molecularly different variant, also with a hymeniform pileus covering and truncate to spurred spores, was discovered, but this variant is not morphologically distinguishable from *L. cristata*.

Keywords – Cryptic species, ITS-sequences, IGS1-sequences, California mycota

INTRODUCTION

Lepiota cristata (Bolton: Fr.) Kumm. was sampled from Europe, North America and China to study the variation in ITS-sequences as part of a research project assessing the phylogenetic relationships within and between the tribus Lepioteae Fayod and Leucocoprineae Singer within the family Agaricaceae (Fr.) Chevall. as recognized and defined by Singer (1986). Several distinct ITS-types were discovered, accompanied by phenotypical differentiation in one case.

MATERIAL AND METHODS

Material – Collections of *L. cristata* from a wide distribution area were sampled, as well as multiple collections from the same locality. A list of collections studied is given in the Appendix.
Morphology – Colour annotations in the macroscopical descriptions are from Munsell Soil Color Charts (1975). The notation [57,4,3] indicates that measurements were made on 57 spores in four samples in three collections. The following abbreviations are used: avl for average length, avw for average width, Q for quotient of length and width and avQ for average quotient.
Molecular identification – DNA was extracted from fresh and herbarium material; the internal transcribed spacer (ITS) and part of the intergenic spacer (IGS1) of the nuclear ribosomal repeat were amplified by the polymerase chain reaction (PCR) with the fungal specific primers ITS1F and ITS4 (Gardes & Bruns, 1993) for the ITS-region,

and CNL12 and 5SA (Henrion et al., 1992) for the IGS1-region. Sequencing of both strands was performed with an ABI model 377 sequencer (Applied Biosystems, Foster City, California, U.S.A.) using a Thermo Sequenase™ Dye terminator Cycle Sequencing Pre-Mix Kit (Amersham Pharmacia Biotech, Piscataway, New Jersey, U.S.A.); the primers ITS1 or ITS5, ITS2, ITS3, and ITS4 were used for the ITS-region, and CNL12 and 5SA for the IGS1-region. The raw data were processed with the use of DNA Sequencing Analysis v.2.1.2 and Sequence Navigator v.1.0.1 (also of Applied Biosystems). The sequences thus obtained were aligned in ClustalW (online http://www.ch.embnet.org/software/ClustalW.html), with the following settings: opening gap penalty 10, end gap penalty 10, extending gap and separation gap penalty both 0.05. Sequences were analysed using PAUP 4.0b3a (Swofford, 2001). Gaps in the alignment of the IGS1-region were separately coded, following the 'simple indel coding method' as described by Simmons & Ochoterena (2000). Sequences have been deposited in Genbank, and the accession numbers are given in the Appendix.

LEPIOTA CRISTATA VERSUS L. CASTANEIDISCA

Lepiota cristata, a species with a hymeniform pileus covering and truncate to spurred spores, varies in pileus colour from very pale to dark brown, with the typical colour a kind of orange-brown; the annulus is attached to the stipe, but may be absent. Several varieties have been described from Europe (for an overview see Bon (1993)), and one from North America, viz. *L. cristata* var. *viridispora* Kyde & Peterson (1986). *Lepiota cristata* has a wide distribution area and is known from localities all around the Northern Hemisphere. It is also reported from the Southern Hemisphere, but these records may refer to different species (Horak, 1981). It grows especially in ruderal, locally nutrient-rich places, on woodchips, in city-parks, on roadsides etc., and is not commonly found in natural habitats.

The collections chosen for this study, all represent the more typical variant of the species, with orange-brown coloration. Despite this relative uniformity, the ITS-region exhibits considerable variation (Fig. 1). Collections from one area may have different ITS-sequences, whereas the ITS from widely dispersed collections may be identical. No correlation between morphology, geography, and ITS-sequences was found. This may be caused by introduction of the species in suitable, man-made, habitats. *Lepiota magnispora* Murrill, also a widespread but ecologically different species, has three, morphologically and geographically different, ITS-types (Vellinga, 2001b), but this kind of pattern is not present in *L. cristata*.

Collections from forests of *Sequoia sempervirens* (D. Don) Endl. (Redwood), stands of *Cupressus macrocarpa* Gordon (Monterey Cypress) and other natural habitats in northern California that at first were thought to represent *L. cristata,* were examined molecularly. Surprisingly, on the basis of ITS-data, these formed two separate clades which are clearly distinct from *L. cristata* (Fig. 1). The IGS1-data support this (Fig. 2), though the dataset is much smaller. All the collections in these two clades have a hymeniform pileus covering, spores with a truncate to spurred base, and (narrowly) clavate cheilocystidia.

This situation may be compared with a totally unrelated group of fungi, viz. the genus *Sarcodon*, in which differences in ITS-sequences supported chemical and subtle macromorphological differences between two closely related species, which had not been recognized as separate species for over 50 years (*S. squamosus* (Schaeff.) Quél. and *S. imbricatus* (L.: Fr.) P. Karst.) (Johannesson et al., 1999). Just as in our case, the two *Sarcodon* species have different ecological requirements, viz. different host tree species.

A sister group of *L. cristata* was found in *Sequoia sempervirens* forests, and it is macroscopically and microscopically indistinguishable from that species; it is called *Lepiota* sp. in Figs 1, 2, and 4. This provides an example of genotypic differentiation with phenotypic similarity. A description of this taxon is given below. For a comparison with *L. cristata*, the reader is referred to descriptions of *L. cristata* from Europe by e.g. Bon (1993), Candusso & Lanzoni (1990) or Vellinga (2001a).

The second clade, comprising two terminal taxa, is macroscopically distinct from *L. cristata*. It differs in shape and colours of the pileus, viz. convex, lacking a distinct umbo, and reddish or pinkish brown (in the range of 5 YR, whereas the colours in *L. cristata* are in the range of 7.5 YR). These specimens are not recognized as *L. cristata* by European mycologists (e.g. H.A. Huijser, pers. comm.), though they are known under this name in the western U.S.A. (for a picture see Arora, 1986). However, these macroscopical characters are as those given by Murrill (1912) for his *L. castaneidisca* described from a collection found near Searsville Lake, San Mateo Co., California, under *Sequoia sempervirens*. Murrill's description is as follows: "Pileus fleshy, regular, convex, umbonate, gregarious, 1.5-4 cm. broad; surface dry, white, with small, imbricate, avellaneous to light-chestnut scales, the umbo chestnut with unbroken cuticle; lamellae free, white, broad, ventricose, rather close; spores ellipsoid, smooth, hyaline, 5-6 x 3μ; stipe cylindric, equal, hollow, glabrous, brownish-tinted, 4-7.5 cm. long, 3-10 mm. thick; annulus white, superior, delicate, inconspicuous."

Two years later, Murrill (1914) reconsidered his new species, and decided that it was synonymous with *L. cristata,* which he called *L. conspurcata* (Willd.) Morgan; this opinion was shared by Sundberg (1989), who like Smith (1966), studied the type collection. Indeed, the microscopical characters of the type collection are identical to those of *L. cristata*.

My conclusion is that Murrill's collection belongs to the same species as what is called *L. castaneidisca* 1 and 2 in Figs 1 and 2, and that the name *L. castaneidisca* should be used for this species. The ecology supports the use of this name. Murrill's collection was found growing under Redwood, and not in a man-made habitat, as would be the typical habitat for *L. cristata*. However, discriminating morphological characters between the two terminal taxa of the *L. castaneidisca* clade were not found, despite the consistent and significant differences in ITS and IGS1 (Figs 1 and 2). Collections which can be referred to either branch grow together in the same area. A full description of *L. castaneidisca* is given below. One collection, viz. 'ecv2411', is anomalous. It was found on a roadside pile of dirt, and macroscopically represents *L. cristata* in all aspects, although the molecular data suggest that this collection belongs to *L. castaneidisca*. Its characters are not included in the description of *L. castaneidisca* as given here.

Besides those spurred-spored species, very similarly looking species with ellipsoid spores occur in the same localities: *Lepiota thiersii* Sundb. without cheilocystidia, and *Lepiota neophana* Morgan sensu Sundberg (1989) with cheilocystidia have both been reported from Monterey Cypress groves (Sundberg 1989).

It was shown earlier that other lepiotaceous species described from Europe, e.g. *Melanophyllum haematospermum* (Bull.: Fr.) Kreisel, and *Cystolepiota pulverulenta* (Huijsman) Vellinga, are represented by a distinct ITS-type in California habitats (Vellinga, 2001b), though the morphology does not show variation. Further research on different genes is needed to show whether these types represent separate species.

The number of lepiotaceous fungi in Redwood forests and especially in Monterey Cypress stands is high, and these fungi obviously play an important role in the decomposition process. Clearly, when comparing or assessing species diversity it is essential to take into account the morphologically hidden genetic differences.

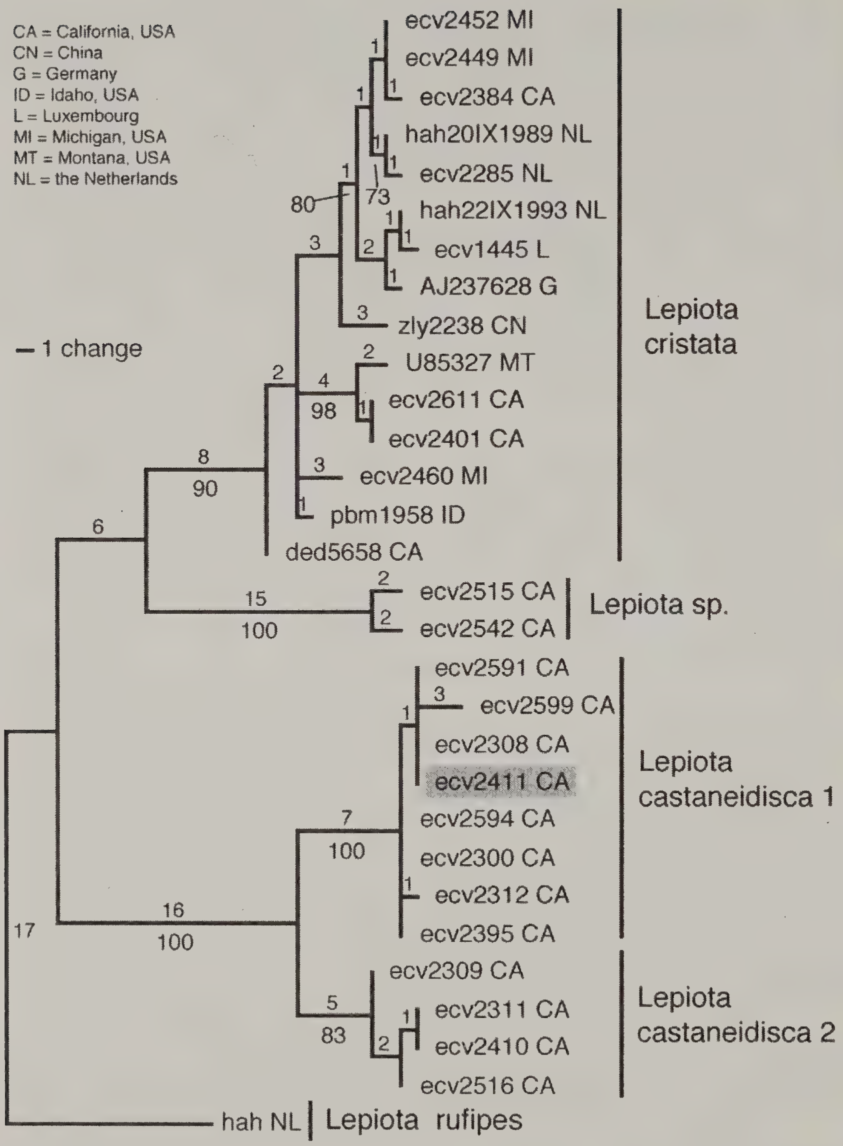
CA = California, USA
CN = China
G = Germany
ID = Idaho, USA
L = Luxembourg
MI = Michigan, USA
MT = Montana, USA
NL = the Netherlands
— 1 change
ecv2452 MI
ecv2449 MI
ecv2384 CA
hah20IX1989 NL
ecv2285 NL
hah22IX1993 NL
ecv1445 L
AJ237628 G
zly2238 CN
U85327 MT
ecv2611 CA
ecv2401 CA
ecv2460 MI
pbm1958 ID
ded5658 CA
Lepiota cristata
ecv2515 CA
ecv2542 CA
Lepiota sp.
ecv2591 CA
ecv2599 CA
ecv2308 CA
ecv2411 CA
ecv2594 CA
ecv2300 CA
ecv2312 CA
ecv2395 CA
Lepiota castaneidisca 1
ecv2309 CA
ecv2311 CA
ecv2410 CA
ecv2516 CA
Lepiota castaneidisca 2
hah NL
Lepiota rufipes
80
73
98
90
100
100
100
83
17

Fig. 1. Relationship between *L. cristata*, *L. castaneidisca*, and *L.* spec., with *L. rufipes* Morgan sensu European authors as an outgroup, based on parsimony analysis of the nuclear ribosomal DNA ITS-sequences. Collections are indicated with the collector's initials and collection number or date, or with a Genbank accession number, and a country or state code. Collection 'ecv2411' (shaded) is morphologically identical to *L. cristata*. One of 300 most parsimonious trees is shown. Bootstrap supports > 70 % are indicated under the branches, based on 500 replicates. The analysis is based on 72 parsimony-informative characters; tree length = 116, CI = 0.7414, RC = 0.6958.

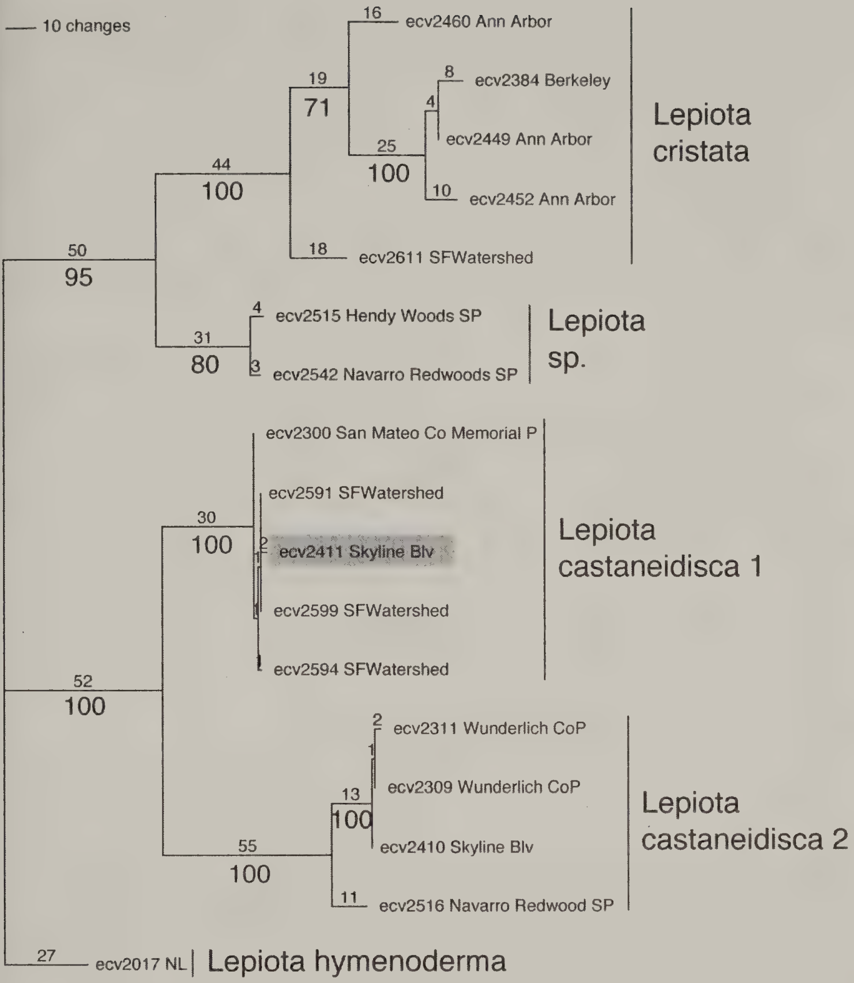
10 changes
16
ecv2460 Ann Arbor
8
ecv2384 Berkeley
4
ecv2449 Ann Arbor
19
71
25
100
10
ecv2452 Ann Arbor
44
100
18
ecv2611 SFWatershed
Lepiota cristata
50
95
4
ecv2515 Hendy Woods SP
31
80
3
ecv2542 Navarro Redwoods SP
Lepiota sp.
ecv2300 San Mateo Co Memorial P
ecv2591 SFWatershed
30
100
2
ecv2411 Skyline Blv
1
ecv2599 SFWatershed
1
ecv2594 SFWatershed
Lepiota castaneidisca 1
52
100
2
ecv2311 Wunderlich CoP
1
ecv2309 Wunderlich CoP
13
100
ecv2410 Skyline Blv
55
100
11
ecv2516 Navarro Redwood SP
Lepiota castaneidisca 2
27
ecv2017 NL
Lepiota hymenoderma

Fig. 2. Relationships between *L. cristata*, *L. castaneidisca*, and *L.* spec., with *L. hymenoderma* D.A. Reid as an outgroup, based on parsimony analysis of the nuclear ribosomal DNA IGS1-sequences. Collections are indicated with the collector's initials and collection number, and the place of origin. Collection 'ecv2411' (shaded) is morphologically identical to *L. cristata*. One of 18 most parsimonious trees is shown. Bootstrap supports > 70 % are indicated under the branches, based on 1000 replicates. The analysis is based on 251 parsimony-informative characters; tree length = 428, CI = 0.7874, RC = 0.7019.

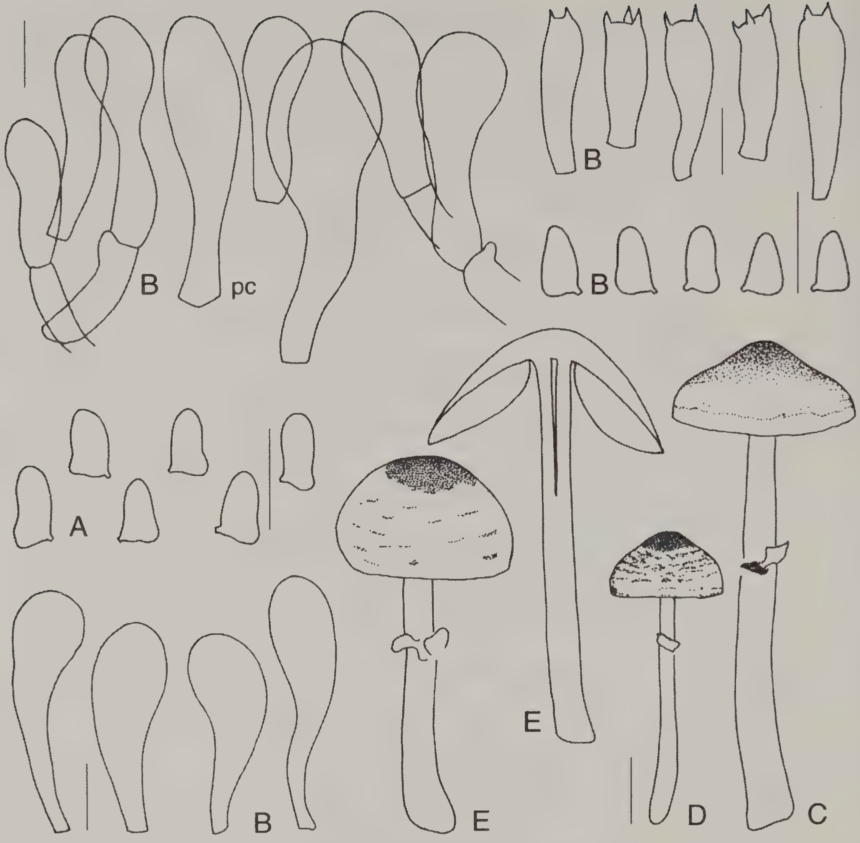

Fig. 3. *Lepiota castaneidisca* – Habitus, spores, basidia, cheilocystidia, and pileus covering (pc). A. from holotype; B. from coll. E.C. Vellinga 2516; C. from coll. E.C. Vellinga 2300; D. from coll. E.C. Vellinga 2395; D. from coll. E.C. Vellinga 2410. Scale bar is 1 cm for basidiocarps and 10 µm for microscopic structures.

DESCRIPTIVE PART

Lepiota castaneidisca Murrill in Mycologia 4: 232. 1912. – Fig. 3.

Pileus 8-32 mm, when young blunt-conical-paraboloid with inflexed margin, expanding via conico-convex, and campanulate-convex to convex with slightly inflexed to deflexed margin, orange reddish, warm (pinkish to reddish) brown to pale orange-brown (2.5 YR 4/4, between 5 YR 5/6 and 2.5 YR 5/8, 5 YR 5-4/6, 7.5 YR 7/8) at centre, in old specimens fading and losing the reddish tinges (c. 7.5 YR 6-5/4-6), smooth and closed, much paler around umbo (5 YR 7/5, 5 YR 7/3, 5 YR 8/4, 7.5 YR 8/5), and splitting up, especially in outer zone, into small pale, sometimes pale pink-cream, concentrical patches, on radially fibrillose whitish background; margin exceeding lamellae.

Lamellae, L = c. 40-45, l = 1-5, moderately crowded to moderately distant, free, slightly ventricose 2.5-5 mm wide, whitish when young, distinctly cream-coloured in older specimens, sometimes with pinkish sheen, with white irregular to fimbriate edge. Stipe 25-65 x 2-6 mm, cylindrical, slightly widened towards base, hollow, lengthwise creamy innately fibrillose, pinkish in lower part, discolouring reddish when bruised, especially in lower half, and in older specimens, with annulus, with white mycelial cords. Annulus ascending when young, in old specimens present as some remmants on stipe, completely brownish or with patches on underside as on pileus, with fringed upper rim, and cottony white inside. Context whitish, white-cream in pileus, firm and dull, in stipe shiny cream to red-brown in old specimens in lower half. Smell strong, sweet fruity-aromatic, of cut basidiocarps with rubber component of the *L. cristata* smell, sometimes with cod-liver oil component. Taste not recorded.

Spores [119,8,8] 5.0-9.0 x 3.0-4.0 µm, avl x avw = 6.4-8.1 x 3.1-3.7 µm, Q = 1.6-2.5, avQ = 1.95-2.2, in side-view triangular, clyindrical with spurred base, in frontal view oblong, hardly congophilous, dextrinoid, not colouring in Cresyl Blue. Basidia 18-30 x 5.0-8.0 µm, 4-spored; a few 2-spored basidia present. Lamella edge sterile; cheilocystidia 20-44 x 6.5-13.5 µm, narrowly clavate, clavate, more rarely cylindrical or spheropedunculate with short to long pedicel. Pleurocystidia not observed. Pileus covering a hymeniderm made up of elements of different length, 16-62 x 8.0-18 µm; most elements colourless, some with brown intracellular pigment, with slightly thickened walls; elements covered by a colourless layer. Stipitipellis a cutis of cylindrical non-coloured hyphae, c. 2.0-3.0 µm wide. Clamp-connections present in all tissues.

Habitat & distribution – Gregarious, terrestrial, and apparently saprotrophic, in *Sequoia sempervirens* groves, in stands of *Cupressus macrocarpa*, and in mixed *Quercus agrifolia* Nee forests. November to January. Widespread in coastal central and northern California.

Lepiota sp. (close to *L. cristata*) – Fig. 4.

Pileus 12-30 mm, campanulate when young, expanding to plano-convex and finally applanate, with low and/or very small umbo, at centre orange-brown, red-brown, or pinkish-orange-brown (c. 5 YR 5/6, 7.5 YR 4/4, 5/6, 6/6), closed and smooth at centre, around centre breaking up into concentrical rings of patches, more irregularly arranged near margin, on whitish background, paler than at centre. Lamellae, moderately crowded, free, slightly ventricose, cream or creamy, with white eroded edge. Stipe 35-60 x 1,5-3 mm, cylindrical, but slightly widened at utmost base, hollow, shiny white innately fibrillose on reddish background in lower half. Annulus in young specimens as a funnel around stipe, sometimes only clinging to pileus margin, later disappearing, white, with brown patches on underside. Smell strong, like *L. cristata*: like rubber and sweet.

Spores [40,2,2] 5.0-7.0 x 3.0-4.0 µm, avl x avw = 6.1 x 3.2 µm, Q = 1.65-2.1, avQ = 1.9, in side-view triangular, clyindrical with spurred base, in frontal view oblong, hardly congophilous, dextrinoid, not colouring in Cresyl Blue. Basidia 20-24 x 6.0-8.0 µm, 4-spored. Lamella edge sterile; cheilocystidia 19-35 x 7.0-11 µm, narrowly clavate, clavate, to spheropedunculate, slightly thick-walled, with refractive contents. Pleurocystidia not observed. Pileus covering a hymeniderm made up of elements of different length, 21-64 x 5.0-14 µm, most elements colourless, some with brown intracellular pigment, with slightly thickened walls; elements covered by a colourless layer. Stipitipellis a cutis of cylindrical, colourless hyphae,2.0-3.0 µm in

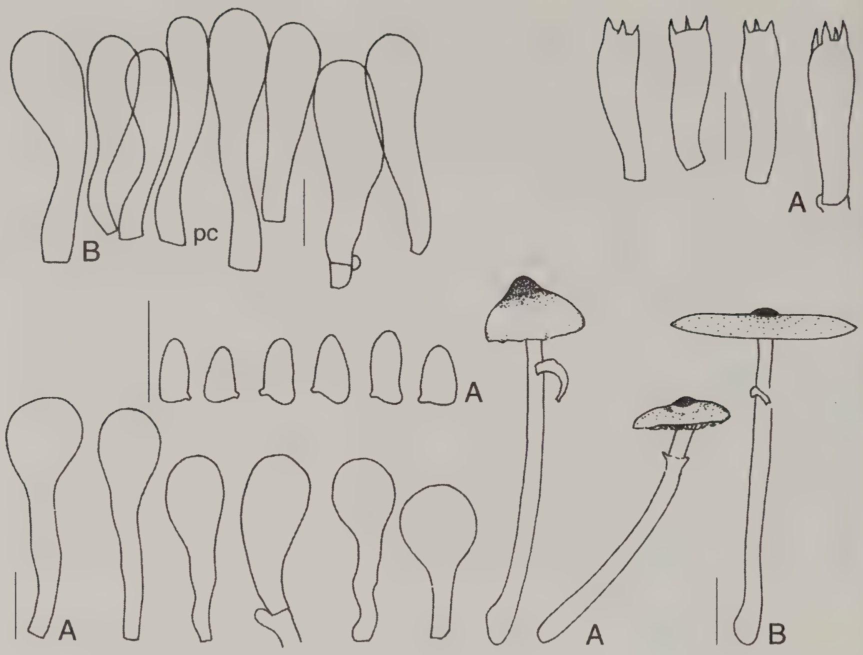

Fig. 4. *Lepiota* sp. – Habitus, spores, basidia, cheilocystidia, and pileus covering (pc). A. from coll. E.C. Vellinga 2542; B. from coll. E.C. Vellinga 2515. Scale bar is 1 cm for basidiocarps and 10 µm for microscopic structures.

diameter. Clamp-connections present in all tissues

Habitat & distribution – In groups, terrestrial, in woods of *Sequoia sempervirens*. November. Known from two localities in Mendocino Co. (California).

ACKNOWLEDGMENTS

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APPENDIX

List of collections examined for this study, and Genbank accession numbers for the ITS- and IGS1-sequences resp. Herbarium abbreviations are according to Holmgren et al. (1990).

Lepiota cristata
China, Sichuan Prov., Xiangcheng Co., in Maxingou near Riying (alt. 3600 m.), 9-VII-1998, Z.L. Yang 2238, AF391044 (HKAS).
Luxembourg, Hollenfels, 28-IX-1988, E.C. Vellinga 1445, AF391027 (L).
The Netherlands, prov. Zuid-Holland, Leiden, 11-X-1998, C. Bas (coll. E.C. Vellinga 2285), AF391048 (L); prov. Noord-Brabant, Eindhoven, Philips de Jong park, 20-IX-1989, H.A. Huijser, AF391043 (L); prov. Limburg, Wijlre, Stokhem, 22-IX-1993, H.A. Huijser, AF391042 (herb. Huijser).
U.S.A., California, Alameda Co., Berkeley, 9-XII-1999, E.C. Vellinga 2384, AF391049; AF391069 (UC); San Mateo Co., San Francisco Watershed, near Pulgar Water Temple, 10-XII-1999, E.C. Vellinga 2401, AF391046 (UC); ibidem, 8-XII-2000, E.C. Vellinga 2611 AF391045, AF391068 (UC); Santa Barbara Co., Los Padres National Forest, Figuarora Campground, 30-I-1993, D.E. Desjardin 5658, AF391050 (SFSU); Idaho, Bonner Co., Priest Lake, 24-IX-2000, S. Clark (coll. P.B. Matheny 1958), AF391051 (WTU); Michigan,

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MYCENA DUNICOLA, A STRIKING NEW SPECIES FROM THE IBERIAN PENINSULA

F. ESTEVE-RAVENTÓS[*], M. VILLARREAL,[**] J.M. BARRASA[*] & A. ORTEGA[***]

[*] Departamento de Biología Vegetal, Universidad de Alcalá, E-28887. Alcalá de Henares, Madrid, Spain. E-mail: fernando.esteve@uah.es

[**] Departamento de Biotecnología Microbiana, Centro Nacional de Biotecnología (CNB-CSIC), Campus Cantoblanco, Universidad Autónoma de Madrid, E-28049. Madrid. Spain. E-mail: mvillarr@cnb.uam.es

[***] Departamento de Biología Vegetal, Universidad de Granada. E-18071. Granada, Spain. E-mail: aortegad@ugr.es

Summary: *Mycena dunicola* is described as a new species belonging to the new section *Dunicolae*. As a whole, this section shows characters such as the arcuate-decurrent lamellae, negative reaction of the lamellar trama in Melzer´s reagent, strongly amyloid spores and presence of pileocystidia. The new species has been found growing on acid, sandy soils in coastal and continental dunes.

Key words: Tricholomatales, *Mycena*, *Mycena* sect. *Dunicolae*, Portugal, Spain.

INTRODUCTION

Mycena dunicola was collected from two different localities of the Iberian Peninsula, firstly in Estremadura, central Portugal, and ulteriorly in Andalucía, southern Spain; in both occassions, the new species was found growing in dunes, either coastal or continental, in *Pinus pinaster* Aiton forests. The sample from Andalucía was found on consolidated continental dunes, in which some degradated plant formations of psammophilous *Quercus suber* forest also developed (*Oleo-Quercetum suberis*).

Strictly sabulicolous representatives of this genus are known to be few; COURTECUISSE (1984) has acknowledged the presence of some species in the atlantic coastal dunes of Northern France, though most of them are considered as ubiquitous praticolous species, e.g. *M. roseofusca* (Kühner) Bon, *M. pseudopicta* (J. E. Lange) Kühner, etc. According to our data from the European Continent, only *M. chlorantha* (Fr. :Fr.) P. Kumm. and *M. erianthi-ravennae* Robich could be considered as strictly sabulicolous, as they have always been recorded from dunes, associated to different species of *Poaceae*. The samples of *Mycena dunicola* were not growing on or among debris of sabulicolous herbs, but directly on sand among bryophytes.

In order to propose the new section and species, an extensive bibliographic search on this genus and close allies, e.g. *Hydropus* (Kühner) Singer, has been made (KÜHNER, 1938; SMITH, 1947; MÉTROD, 1949; PEGLER, 1977, 1983, 1986; MAAS GEESTERANUS & HORAK,1995; GRGURINOVIC, 1997; HAUSKNECHT *et al.*, 1997; MAAS GEESTERANUS & DE MEIJER, 1997; BAS, 1999), but the particular combination of characters of the new taxa do not seem to match any described species.

MATERIAL AND METHODS

The description of *M. dunicola* has been based on the examination of collections containing six fresh specimens from Portugal and one dry specimen from Spain. The material has been deposited in AH and GDA.

The photograph of the basidiomata was taken in the field and light microscopy photographs were made in an Olympus BX50 using bright field and phase contrast. All drawings were made using a camera lucida device. Colours of the basidiomata are referred to MUNSELL (1994) and spore measurements follow the method proposed by HEINEMANN & RAMMELOO (1985). Authors abbreviations are according KIRK & ANSELL (1992).

Mycena sect. ***Dunicolae*** M. Villarreal, Esteve-Rav., Barrasa & A. Ortega, ***sect. nov.***

Basidiomata statura parva vel media. Pileus udus lubricus, flavus, aurantiacus vel olivaceus. Lamellae pauceae, molles, arcuatae vel decurrentibus, flavo-olivacea, margine concolores. Stipes fragilis, udus lubricus, pileo pallidior, puberulus, fibrillis substrato affixus.
Basidia clavata, 4-sporigera, fibulata. Sporae subglobosae, leves, amyloideae. Cheilocystidia et pleurocystidia fibulata, leves, ampullacea. Trama lamellarum iodi ope haud vinescens. Hyphae pileipellis fibulatae, leves vel leviter diverticulatae. Pileocystidia ampullacea. Hyphae stipis corticales fibulatae, leves vel leviter diverticulatae. Caulocystidia cheilocystidia similia, descendentia ad basim.
Terricola
Species typica: Mycena dunicola.

Basidiomata small to medium-size. Pileus lubricous, yellowish, orange to olivaceous. Lamellae distant, arcuate to decurrent, olivaceous-yellow, with concolorous edge. Stipe fragile, lubricous, paler than the pileus, finely pruinose, fibrillose at the base.
Basidia clavate, 4-spored, clamped. Spores subglobose, smooth, amyloid. Cheilocystidia and pleurocystidia clamped, non diverticulate, ampullaceous. Hymenophoral trama non dextrinoid. Hyphae of the pileipellis clamped, smooth or with isolated diverticules. Pileocystidia ampullaceous. Hyphae of the stpitipellis clamped, smooth or with lateral isolated projections. Caulocystidia similar to cheilocystidia, descending to base.
Terricolous
Type species: *Mycena dunicola*

Mycena dunicola Esteve-Rav., M. Villarreal, Barrasa & A. Ortega, ***spec. nov.*** (Figs 1-10).

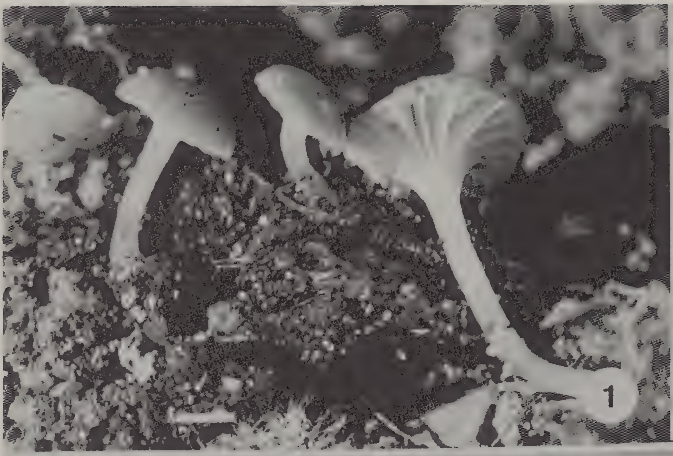
Basidiomata gregaria vel dispersa. Pileus 7-15 mm latus, convexus vel plano-convexus, centro depressus, leviter striatus, lubricus, flavus, aurantiacus vel olivaceus. Caro tenuis, odore indistincto, sapore ignoto. Lamellae 13-19 stipitem attingentes, usque ad 2 mm latae, pauceae, molles, arcuatae vel decurrentibus,

flavo-olivacea, margine concavae, concolores. Stipes 8-43 x -0.8-1,5 mm, cavus, fragilis, cylindraceus, udus lubricus, flavo-olivaceus, pileo pallidior, minute puberulus, basi fibrillis albis substrato affixus. Basidia clavata, 4-sporigera, fibulata. Sporae 7,5-9 x 5,5-7,5 µm, subglobosae, leves, amyloideae. Cheilocystidia 35-65 x 5-12 x 1,5-3 µm, fusiformia vel ampullacea, interdum furcata, levia, fibulata. Pleurocystidia sparsa, similia. Trama lamellarum iodi ope haud vinescens. Hyphae pileipellis 3-6 µm latae, fibulatae, leves, parum gelatinosae. Pileocystidia 30-45 x 7-10 µm, fibulatae, leves, ampullacea. Hyphae stipis corticales 1,5-3,5 µm latae, fibulatae, leves, caulocystidia diversiformia, descendentia ad basim.
In terram sabulosam

Holotypus: AH 26939; Paratypus: GDA 43817.

Basidiomata gregarious. Pileus 7-15 mm in diam., hemisphaerical to convex, not umbonate, slightly depressed with age, hygrophanous, not sulcate, slightly translucent-striate at the margin, pruinose glabrescent, lubricous when wet, uniformly yellow (Mu 5Y 7/8) to olive yellow (5Y 6/6-8), sometimes paler at the margin, drying to dark olive gray (5Y 3/2-3). Lamellae 13-19, lamellulae 1-3, -2 mm wide, pale yellow (5Y 8/4), showing an olivaceous tinge, drying olive gray to olive (5Y 4/2-3), arched to deeply decurrent, with concave and concolorous edge. Context thin, whitish yellow. Smell banal and taste unknown. Stipe 8-45 x 0.8-1,5 mm, hollow, cylindrical or slightly broadened towards the base (-1.7 mm), pale yellow to lemon yellow (5Y 8/8) sometimes with olivaceous tinges, paler than the pileus, pruinose under the lens, slightly lubricous when wet, with the base covered by long interwoven whitish to pale yellow fibrils including grains of sand.
Basidia 32-36 x 7-9 µm, clavate, 4-spored, clamped at the base. Spores 7.5-8.31-9 x 5.5-6.57-7.5 µm; Q = 1.06-1.27-1.55(-1.63); (n=21), subglobose to broadly ellipsoid, smooth, amyloid. Cheilocystidia 35-65 x 5-12 x 1.5-3 µm, hyaline, clamped, fusiform, lageniform, short stalked, frequently with a single or ramified long and acute neck, smooth, forming a nearly sterile band (lamella-edge heterogeneous). Pleurocystidia sparse, similar to cheilocystidia in shape and size. Hymenophoral trama not dextrinoid, made up of hyphae 10-25 µm wide. Subhymenium made up of hyphae 4-7 µm wide. Hyphae of the pileipellis smooth, 3-6 µm wide, clamped, ocassionally with some sparse, simple to furcate diverticules (-15 x 1.5-4 µm), slightly gelified. Pileocystidia 30-45 x 7-10 µm, sparse, protruding among the cutis. Hypoderm made up of parallel, more or less inflated hyphae up to 35 µm wide. Stipitipellis constituted by hyphae of 1.5-3.5 µm, smooth or showing some sparse simple or forked lateral projections, clamped, slightly gelified, with fairly numerous lateral and terminal caulocystidia 30-75 x 5-8 µm. Hyphae of the cortical layer of the stipe up to 8.5 µm wide, not showing sarcodimitic structure. Oleiferous hyphae absent.

Material studied: **Portugal**: *Estremadura*, Marinha Grande, San Pedro de Moel, Pedras Negras, 29SME9803, 20 m. alt., Leg. *F. Esteve-Raventós, J.C. Salom* & *L.A. Parra*, 7-XI-2000, in coastal dunes, on bare sand among mosses under *Pinus pinaster* Aiton., AH 26939 (Holotype). **Spain**: *Sevilla*, Aznalcázar, road from Aznalcázar to Isla menor, 30SQB2545, Leg. *L. Alcoba* & *A. Ortega*, 2-XII-2000, on sandy acid soils, among plant debris and mosses, under *Pinus pinaster* forest, GDA 43817 (Paratype).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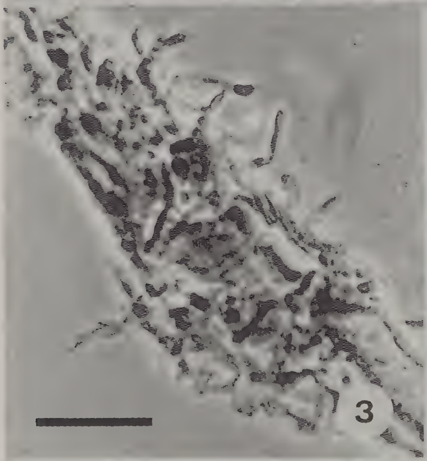
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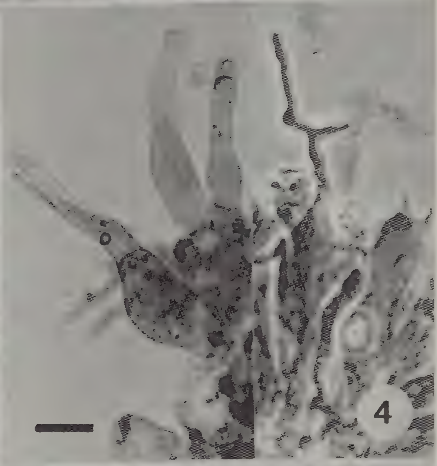
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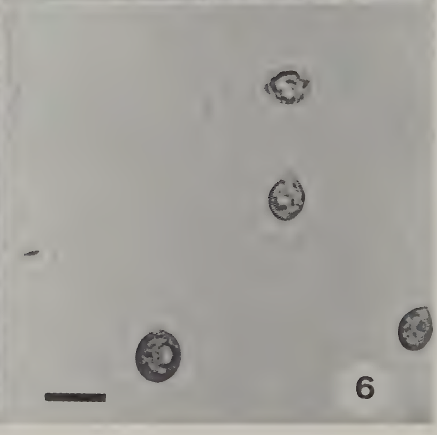
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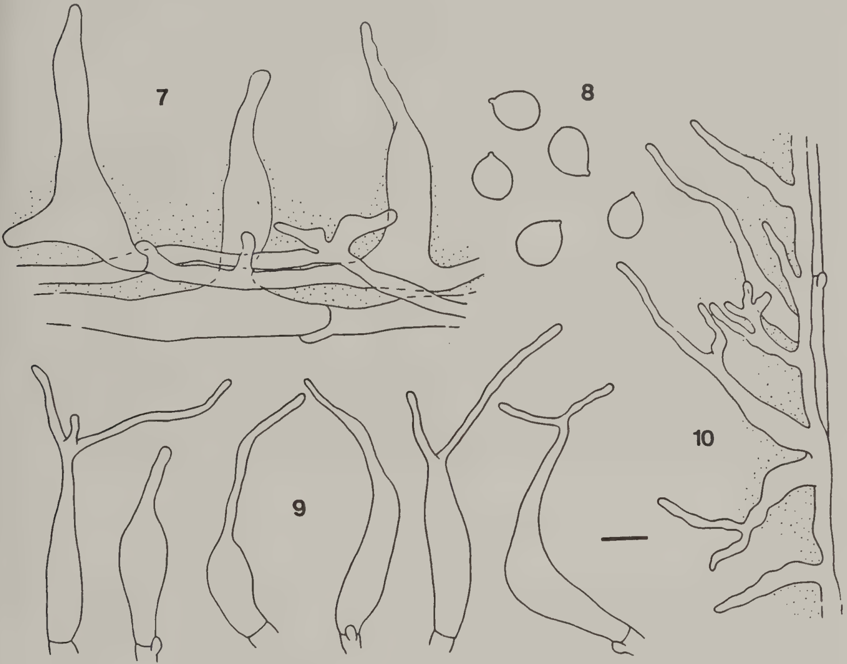
DISCUSSION

Macroscopically, *M. dunicola* shows a typical "hygrocyboid" to "omphalinoid" habit on the basis of its colours and distant, deeply arcuate-decurrent lamellae; the amyloid character of the spores, however, is a feature not present in either *Hygrocybe* (Fr.) P. Kumm. or *Omphalina* Quél., but in many *Mycena* (Pers.) Roussel species. Apparently, this new species might be classified as a member of sect. *Hiemales* Konrad & Maubl., and more particularly of subsect. *Omphaliariae* Kühner ex Maas Geest. on account of the non dextrinoid reaction of the hymenophoral trama, as well as the lamellar insertion; however, the amyloid spores exclude this possibility, as well as the presence of protruding dermatocystidia.



Figs. 7-10. *Mycena dunicola* (AH 26939, holotype). **Fig. 7.** Pileipellis. **Fig. 8.** Spores. **Fig. 9.** Hymenial cystidia. **Fig. 10.** Stipitipellis. Bar= 10 µm.

Figs 1-6. *Mycena dunicola* (AH 26939, holotype). **Fig. 1.** Fruitbodies. **Fig. 2.** Pileocystidium. **Fig. 3.** Caulocystidia. **Fig. 4.** Cheilocystydia. **Fig. 5.** Basidia. **Fig. 6.** Spores. Bars: Fig. 1= 5 mm; Fig. 3= 75 µm; Figs. 2, 4, 5 and 6= 9 µm.

Section *Dunicolae*, together with sections *Radiatae* Singer *emend* Maas Geest. (MAAS GEESTERANUS, 1985), *Diversae* Maas Geest. & de Meijer and *Nodosae* Maas Geest. & de Meijer (MAAS GEESTERANUS & DE MEIJER, 1997) shows a particular position within the genus. These four sections are characterized by the amyloid spores and non dextrinoid hymenophoral trama. In the key to the Northern Hemisphere *Mycena* sections (MAAS GEESTERANUS, 1992), *Mycena dunicola* would key out near sect. *Radiatae*, but cheilocystidia, pleurocystidia and pileocystidia are absent in *M. radiata* (Dennis) Singer ex Maas Geest. and macroscopically shows a very different appearance. On the other side, the South American section *Nodosae* differs by having a stipe arising from a basal disc, lamellae adnate, and diverticulate cheilocystidia and hyphae of the pileipellis. Section *Diversae* (also South American) seems to be the closest, but shows a different pileipellis structure and absence of pleurocystidia. In our opinion, the combination of characters of *M. dunicola* justify the recognition of a new section. A comparative table between the most related sections is presented below (Table I).

Table I. A comparison between sections *Diversae, Nodosae, Radiatae* and *Dunicolae*.

section	lamellar insertion	spores	pileocystidia	cheilo-pleurocystidia
Diversae	decurrent	subcylindrical	absent	non diverticulate
Nodosae	adnate	ellipsoid	absent	diverticulate
Radiatae	free	ellipsoid	absent	absent
Dunicolae	decurrent	subglobose	present	non diverticulate

The absence of dextrinoid reaction in any part of the fruitbodies and the presence of pileocystidia, also made us to consider a possible taxonomic relationship with the genus *Hydropus*; however, the following combination of characters: 1) absence of a sarcodimitic tissue in the stipititrama, 2) absence of broadly rounded dermatocystidia with vacuolar pigment, 3) presence of slightly gelified layer in the epicutis and 4) absence of oleiferous hyphae, are overall features more easily accommodated within the genus *Mycena*.

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MATERIALS FOR A HYPOGEOUS MYCOFLORA OF THE GREAT BASIN AND ADJACENT CORDILLERAS OF THE WESTERN UNITED STATES. III: SAPROPGASTER GEN. ET SP. NOV. (BASIDIOMYCOTA, PHALLALES)

Robert Fogel
University of Michigan Herbarium, North University Building,
Ann Arbor, Michigan 48109-1057, USA

Jack States[1]
Department of Botany, University of Wyoming, Laramie Wyoming
82071, USA

ABSTRACT

A new hypogeous genus and species of the Phallales collected in Great Basin Conifer Woodland vegetation-type under piñon (*Pinus edulis or P. monophylla*) in Utah and Arizona are described and illustrated.

Key Words: Arizona, false-truffle, sequestrate, Utah.

This is the third in a series containing materials for a hypogeous mycoflora of the Great Basin and adjacent cordilleras (Fogel 1994, Fogel and Pacioni, 1989, Fogel and States in prep.). These reports plus a few others (Fogel 1992, Kropp and Hutchison 1996) and publications on Arizona mycoflora by States (States 1983, 1984, 1991) provide the foundation for a broader understanding of the biogeography and host relationships of hypogeous fungi in the Intermountain Region. These publications indicate that hypogeous fungi can be found throughout the 714,854 square km region wherever suitable hosts are found and when there is sufficient moisture present during the growing season. Sufficient moisture can pose a serious problem in collecting since summer precipitation averages from 50 to 200 mm in the Region (Cronquist et al 1972), but varies greatly both locally and from year to year.

The Great Basin Conifer Woodland (122.4) vegetation-type is one of the most common in the Intermountain Region (Brown 1994). Rocky Mountain piñon (*Pinus edulis* Engelm.) and singleleaf piñon (*P. monophylla* Torr. & Frėm.) are the major putative mycorrhizal hosts in this vegetation-type.

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[1] Address for correspondence: 2 Canyon Shadows Rd., Lander, WY 82520.

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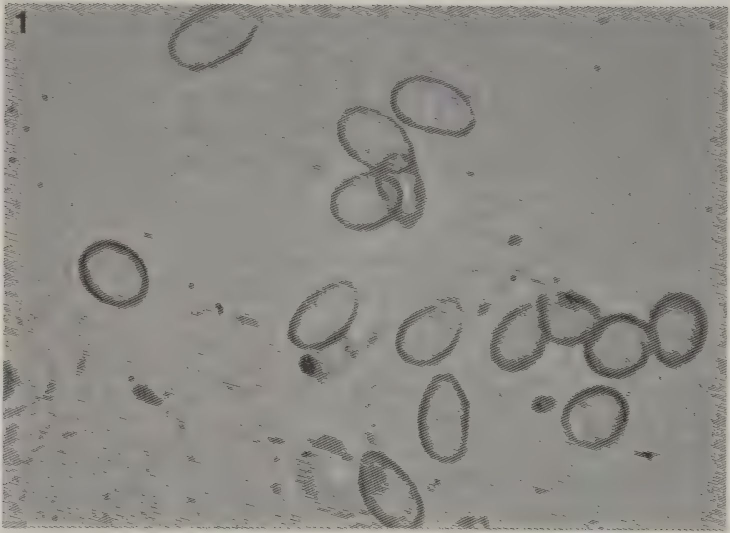

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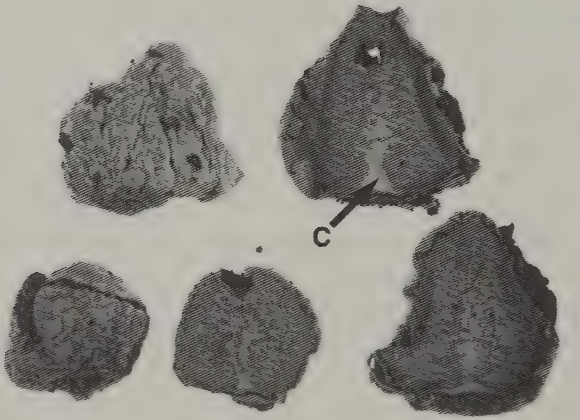

Independent collecting by the authors in the Great Basin Conifer Woodland of Utah and Arizona produced two collections of a taxon differing significantly from *Hysterangium* and *Trappea*, hypogeous members of the Phallales commonly associated with piñon.

MATERIALS AND METHODS

Methods of collection and study of the morphological and anatomical features are essentially those of Smith (Smith and Zeller, 1966). Spores were measured in freehand sections mounted in Melzer's reagent. Lengths and widths of 20 spores randomly selected from a mature basidioma in each collection were measured for statistical comparisons (Fogel 1992b). Color names are given as the ISCC-NBS names with the numerical equivalent in parentheses (Kelly and Judd, 1965). Herbarium names are abbreviated according to Holmgren, Holmgren, and Barnett (1990).

SAPROGASTER Fogel & States, gen. nov. Figs. 1-2.

Basidiomata subglobosa. Peridium alba, glabra, separabile, duplex: stratum myceliale stratum parenchymatum usque pseudoparenchmatum. Gleba gelatina, ochracea. Columella capitata. Sporae laeves, ellipsoideae vel obovatae, hylinae.

Type species: *Saprogaster pinyonensis* Fogel & States

Etymology: Sapros (Greek, rotten, putrid) and gaster (Greek, belly). Name derived from the strong, unpleasant odor of the Utah basidiomes and the soil surrounding them.

SAPROGASTER PINYONENSIS Fogel & States, sp. nov. Figs. 1-2.

Basidiomata usque 20 x 20 x 15 mm, subglobosa. Peridium 750-2000 µm crassum, albus, stratus: epicute, myceliale, 90-200 um crassum, hyphis 2-3 µm diam.; subcute parenchymatum usque pseudoparenchmatum, 250-700 µm crassum, hyphis 4-5 µm diam. usque 30 µm diam. Gleba ochracea. Columella capitata. Sporae laeves, ellipsoideae vel obovatae, 6-7 x 4-5 µm, hylinae. Holotypus: USA, Arizona, Apache Co., States AHF-425 (MICH).

Etymology: named for piñon, the putative ectomycorrhizal host.

Figs 1-2. *Saprogaster pinyonensis.* **Fig. 1.** Basidiospores mounted in Melzer's reagent, X1600 (Fogel F3725). **Fig. 2.** Dried basidiomes (Fogel F3725) showing the capitate columella (C), X1.8. Note that the epicutis readily separates from the subcutis on drying.

Basidiomata subglobose, up to 20 x 20 x 15 mm. **Peridium** 0.75 to 2.0 mm thick, thickest at base; white to light orange yellow (70) fresh, ochraceous where bruised, farinaceous with some small scurfy patches which incorporate litter debris and white concretions of crystaline filaments and flakes, separable, especially on drying. **Gleba** light yellow brown (76), locules small, up to 320-350 x 70-90 μm, empty, radiating towards the surface, trama translucent, grayish with a pale lilac tint, drying light ochraceous brown, cut surface of fresh basidiocarps sticky. **Columella** 10 x 1 mm wide, capitate, extending halfway into gleba, branches radiating to peridium, splitting to produce a central hollow chamber (especially on drying), pale orange yellow (73), slightly lighter in color than the peridium. Basidiomata attached by a basal rhizomorph, concolorous with peridium, slightly concave around point of attachment. **Odor** mild to strong and unpleasant, intensifying during drying of the basidiomata over an electric coil. **Chemical reactions** of peridium not recorded.

Basidiospores longitudinally symmetric, ellipsoid to obovate, (5.0-) 6-7 x (3.5-) 4-5 μm wide, mean lengths 5.8 ± 0.7 to 6.6 ± 0.5 μm, mean widths 4.1 ± 0.2 to 4.7 +0.4 μm, mean length to width ratio 1.40 to 1.44, 20 spores measured per collection, smooth, lacking a utricle, nearly hyaline in KOH, light yellow in Melzer's reagent, thin-walled (<0.5μm), base truncate, scar 1-2 μm broad. **Basidia** 15-35 (-40) x (3-)6-8.5 μm broad, cylindrical to elongate-clavate, thin-walled, 4-6-spored, spores sessile, deliquescing at maturity. Basidioles not observed. **Locules** 125-200 μm broad in KOH. **Trama** 75-110 μm wide, composed of interwoven hyphae 3-5 μm broad at septum, cells becoming inflated to 12 μm broad, a few clamps present, larger ≤ 25 μm broad clavate cells present on surface of trama. Hymenium obscured by spores. **Peridium** 340-900 μm thick, two-layered. Epicutis 90-200 μm thick, composed of interwoven, thick-walled (1-2 μm) hyphae 2-3 (-5) μm broad, light yellow in KOH, deep orange in Melzer’s reagent. Colorless, non-defined crystals scattered throughout. Subcutis 250-700 μm thick, parenchymatous, composed of hyaline, thin-walled, 4-5 μm diam. hyphae just below epicutis, cells becoming inflated to 30 μm diam., occasionally forming sphaerocysts, finally forming a pseudoparenchymatous zone 80-100 μm thick next to gleba. No “nest” of basidoles present. **Columella** composed of interwoven, hyaline, thick-walled (1-2 μm) hyphae 3-6 um broad at septa, embedded in a granular matrix, no swollen cells or clamp connections present.

Material examined: USA, **ARIZONA, Apache Co.,** States AHF-425(Holotype). **UTAH, Beaver Co.**, Fogel F3725 (all MICH).

Putative mycorrhizal hosts and phenology: Hypogeous under Rocky Mountain piñon (*Pinus edulis*) and singleleaf piñon (*P. monophylla*) in the

Great Basin Conifer Woodland (122.4) vegetation-type (Brown 1994). Fruiting from late May to late June at 2459-2469 m elevation.

Discussion: *Hysterangium* and *Trappea*, hypogeous members of the Phallales, are both commonly collected in the Intermountain Region. *Hysterangium* is one of the three most common hypogeous genera collected in the Great Basin. *Trappea* is less commonly collected. A further comparison of *Saprogaster* to published descriptions of other hypogeous genera of the Phallales shows that it is unique.

Saprogaster has definite phalloid features such as a gelatinous gleba, smooth, ellipsoid to obovoid spores, and a thick, separable peridium. *Saprogaster* differs from other hypogeous members of the Phallales in a number of features. In contrast to *Hysterangium*, *Saprogaster* has a light yellow brown gleba lacking any hint of green, olive, or red shades, the columella is non-gelatinous and capitate rather than dendroid, and the spores lack a utricle. *Saprogaster* differs from *Trappea* in not having a green or olive-green gleba, in having a capitate, non-gelatinous columella, and not having "nests" of sterile basidioles in the peridium. Of all the hypogeous Phallales, *Saprogaster* most closely resembles *Protubera*, but lacks the “sutures” in the peridial subcutis connecting the epicutis to glebal locules in *Protubera* (Castellano and Beever 1994, Malloch 1989).

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MYCOTAXON

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MATERIALS FOR A HYPOGEOUS MYCOFLORA OF THE GREAT BASIN AND ADJACENT CORDILLERAS OF THE WESTERN UNITED STATES IV: ZELLEROMYCES ROGERSONII, SP. NOV. (BASIDIOMYCOTA, ELASMOMYCETACEAE)

Robert Fogel
University of Michigan Herbarium, North University Building,
Ann Arbor, Michigan 48109-1057

Jack States[1]
Department of Botany, University of Wyoming, Laramie, Wyoming
82071

ABSTRACT

A new hypogeous basidiomycete, *Zelleromyces rogersonii,* associated with *Pinus flexilis* from western Nevada, United States, is described and illustrated. The putative ballistosporic discharge of its spores raises some questions about the circumscription of the gastroid families Russulaceae and Elasmomycetaceae in the Russulales.

Key Words: Elasmomycetaceae, false-truffle, Russulaceae, sequestrate.

This is the fourth in a series containing materials for a hypogeous mycoflora of the Great Basin and adjacent Cordilleras (Fogel 1994, Fogel and Pacioni, 1989). The Great Basin, as defined by Cronquist et al. (1972), occupies an area of 714,854 square km. The vegetation in the Region contains many suitable ectomycorrhizal hosts for hypogeous fungi patchily distributed. The species composition of a specific stand reflects the interaction of environmental optima for species, soil factors, pre-glacial flora, extent of glacial advance, pluvial lake levels, and subsequent re-invasion from glacial refugia (Wells, 1983). Another significant factor affecting the presence of hypogeous fungi is the efficiency of mycophagous rodents, and perhaps insects, in spore dispersal.

Our survey of the Great Basin and adjacent Cordilleras involves collecting in a large number of habitats. One of the more interesting habitats is subalpine conifer forest dominated by bristlecone pine (*Pinus longaeva* D. K. Bailey) and limber pine (*P. flexilis* James). These open forests are widely scattered among the forest islands of the Great Basin (Wells 1983). We were interested in these stands because both pines are putative hosts for ectomycorrhizal truffles and false-truffles.

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[1] Present address: 2 Canyon Shadows Rd., Lander, WY 82520, USA.

A new *Zelleromyces*, *Z. rogersonii*, was collected during one trip to the Wassuk Range Mountains in western Nevada, near Hawthorne. The stand occupies the south slope of a high ridge at 2995 m elevation. The forest cover is fairly uniform and is dominated by large limber pines with the rarer bristlecones scattered throughout. *Picea* and *Abies* are absent. Biogeographically the stand is interesting because migration routes to similar stands to the East in the central Great Basin are blocked by the Lahonten trough, a long, wide trough at 600-1500 m elevation (Wells, 1983). The Lahonten trough would have been filled with water during maximum glacial extent blocking dispersal of truffles. Today the trough is a dry basin dominated by cold desert shrubs. The shrubs are endomycorrhizal and thus cannot serve as intermediate hosts of ectomycorrhizal truffles in long-range dispersal. The change from forest to shrub ecosystems also inhibits movement of rodent mycophagists dispersing spores. Brown (1971) has reported that boreal mammals in the Great Basin are restricted to specific vegetation zones. We visited this stand on numerous occasions, but unfortunately only found *Z. rogersonii* once. We feel that it is sufficiently distinct to describe it as a new taxon although more collections would certainly be desirable.

This is the first, non-stipitate sequestrate member of the Russulales collected in the Great Basin. The paucity of Great Basin records may reflect both the intensity of collecting and the virtual absence of hosts (*Picea engelmannii* Parry & Engelm., *Abies bifolia* Murray, *Pinus ponderosa* Laws., *Pseudotsuga menziesii* (Mirb.) Franco) over most of the region. Six species of *Macowanites* and four *Martellia* species are reported from the the "mainland forests" containing *Abies*, *Picea* and *Pseudotsuga* in the Rocky Mountains of Idaho (Singer and Smith 1960). Two species of *Martellia* have been reported from the pine forests of Arizona (States 1984). The vegetation of the Wassuk Range is more similar to that of the Sierra Nevada than the Great Basin and we expect *Z. rogersonii* may be present in California as a result.

MATERIALS AND METHODS

Methods of collection and study of the morphological and anatomical features are essentially those of Smith (Smith and Zeller, 1966). Spores were measured in freehand sections mounted in Melzer's reagent. Lengths and widths of 20 basidiospores randomly selected from a mature basidioma were measured for statistical comparisons. Color names are given as the ISCC-NBS names with the numerical equivalent in parentheses (Kelly and Judd, 1965). Herbarium names are abbreviated according to Holmgren, Holmgren, and Barnett (1990).

Spores were transferred directly to aluminum stubs for scanning electron microscopy by brushing the surface of dried basidiomes. The spores were then sputter coated with approximately 100 Å of gold:pallidium alloy (60:40) and photographed with a Hitachi S3200N SEM.

ZELLEROMYCES ROGERSONII Fogel & States, sp. nov., Figs, 1-4.

Gastrocarpis 23 x 22 x 18 mm, subglobosis, albus; sporae 8-9 x 6-7 µm, ellipsoideis, reticulatione incompleta, amyloideis, ballistosporicae. Holotypus: USA, Nevada, Mineral County, 12 July 1983, R. Fogel F4684 (MICH).

Etymology: In honor of Dr. Clark T. Rogerson, an indefatigable collector of Great Basin fungi.

Basidioma 23 x 22 x 18 mm., subglobose, surface rough, peridium lacking, showing a network of ridges composed of the tramal plates, showing locules, white. **Gleba** white, locules labyrinthiform, empty, large 0.5-1 mm broad as dried. **Consistency** soft, crumbling during sectioning after being dried. **Columella** absent. Basidioma attached by a tuft of fine basal rhizomorphs.

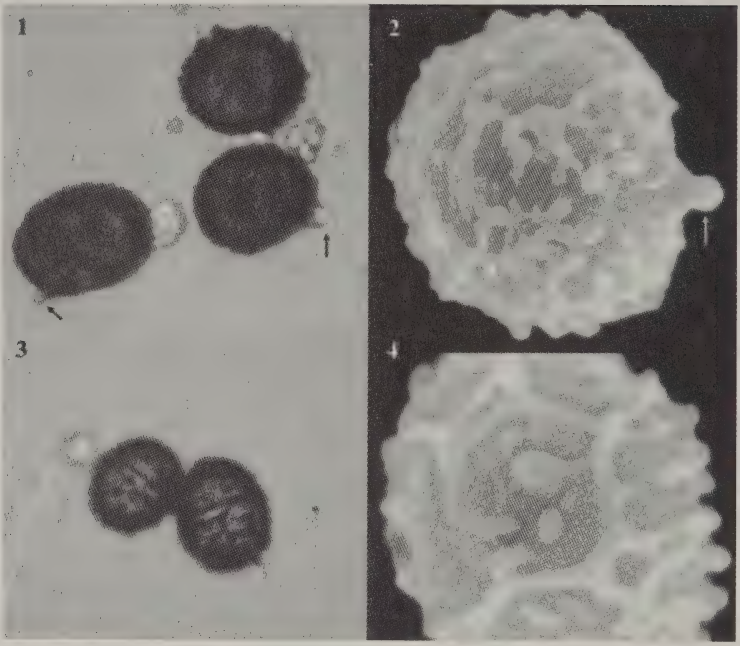
Spores broadly ellipsoidal, 8-9 x 6-7 µm including ornamentation, mean length 8.4 ± 0.5 um, mean width 6.7 ±0.4 um, L/W 1.25, n = 20 spores; hyaline; ornamentation an incomplete reticulum composed of amyloid lines ±0.5 µm high oriented perpendicular to long axis, wall ±0.5 µm thick, amyloid; hilar appendix oblique, conical, tapering to a fine, sometimes blunt, point, hyaline, 1 x 1 um. **Basidia** clavate, 35-44 x 10-11 µm; 4-spored, hyaline, thin-walled, not clamped at base; sterigmata curved, conical tapering to a fine point, 3-4 x 2 µm at base. **Basidioles** clavate, 24-45 x 7-9 um, hyaline, thin-walled, not clamped at base. **Subhymenium** pseudoparenchymous, composed of hyaline, 7-10 x 4-8 µm, thin-walled cells. **Trama** mediostratum 15-20 µm wide, composed of hyaline, 3-4 µm broad, thin-walled, subparrallel hyphae, clamps absent. Sphaerocysts lacking. Abundant lactiferous hyphae 4-5 µm in diam. interwoven among trama and extending into hymenium, content of cells dark yellow in Melzer's reagent, brown in KOH. **Peridium** evanescent, absent after drying.

Probable mycorrhizal host: *Pinus flexilis* (limber pine).

Phenology and distribution: Mid July. Known only from the type locality in the Wassuk Range, SW of Hawthorne, Nevada.

Collections examined: NEVADA, Mineral County, 12 July 1983, R. Fogel F4684 (MICH: Holotype).

Notes: Latex production was not noted when fresh sporocarp was sectioned. The presence of pigment on the cut ends of tramal plates in the dried sporocarp suggests there was some latex production after the fresh



Figs. 1-4. *Zelleromyces rogersonii.* **Fig. 1.** Heterotrophic basidiospores mounted in Melzer's reagent showing eccentric insertion of hilar appendage (arrow), X2,580. **Fig. 2.** SEM of basidiospore showing eccentric hilar appendage (arrow) and partially reticulate ornamentation, X5,332. **Fig. 3.** Heterotrophic basidiospores mounted in Melzer's reagent showing partially reticulate ornamentation, X2,580. **Fig. 4**. SEM showing detail of partially reticulate ornamentation composed of low connectives and irregular warts, X6,708.

sporocarp was sectioned. Placed in *Zelleromyces*, despite the lack of data on latex production, on the basis of abundant lactiferous hyphae in the trama and lack of spherocysts in the trama. Differs from other *Zelleromyces* species by the spores being putatively ballistosporic (oblique hilar scar), the spore size, and spore ornamentation. The ballistosporic spores are the first described in the genus, but are not surprising given that the genus is related to mushroom producing genera. The position of the sterigmata on the basidium appears to be intermediate between heterotrophic and orthotrophic. *Arcangeliella* considered by many authors to be more closely related to *Russula* than is *Zelleromyces* often has asymmetric spores and curved sterigmata (Lebel and Trappe 2000).

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MYCOTAXON

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MATERIALS FOR A HYPOGEOUS MYCOFLORA OF THE GREAT BASIN AND ADJACENT CORDILLERAS OF THE WESTERN UNITED STATES. V: INTRODUCED TRUFFLES AND FALSE-TRUFFLES

Robert Fogel
University of Michigan Herbarium, North University Building,
Ann Arbor, Michigan 48109-1057, USA

Jack States[1]
Department of Botany, University of Wyoming, Laramie, Wyoming
82071, USA

ABSTRACT

Three hypogeous fungi are reported from a small stand of Douglas-fir and lodgepole pine planted in 1936 by the Civilian Conservation Corps in the Santa Rosa Range, Nevada. The fungi were probably introduced as ectomycorrhizal symbionts on the roots of seedlings from Utah. The distances to the nearest native stands of trees are too far for rodent transport of inoculum. Other exotic fungi may be expected wherever ectomycorrhizal trees have been planted.

Keywords: false-truffle, *Barssia oregonenesis, Geopora cooperi* f. *cooperi*, *Hysterangium crassum*, sequestrate, truffle.

As part of an on-going survey of truffles and false-truffles of the Great Basin, the Santa Rosa Mountains in Humboldt County, Nevada have been visited several times (Fogel 1994, Fogel and Pacioni 1989). The Santa Rosa Mountains are a typical Great Basin Range separated from other ranges by dry pluvial lake basins supporting cold desert vegetation. The result is a "forest island" harboring ectomycorrhizal trees, potential hosts for taxa producing truffles and false-truffles, separated by vast stands of endomycorrhizal plants that pose a significant barrier to dispersal of truffles and false-truffles.

Over the course of several years and repeated visits to the Santa Rosa Mountains, two stands of trees have yielded truffles and false-truffles. One is a stand of limber pine, *Pinus flexilis* James, on Buckskin Mountain, the second is a small stand of Douglas-fir, *Pseudotsuga menziesii* (Mirb.) Franco, and lodgepole pine, *Pinus contorta* Dougl. ex Loud., on Martin Creek. The Martin Creek stand has yielded two truffles: *Barssia oregonensis* Gilkey, a Douglas-fir associate (Trappe, 1971), *Geopora cooperi* Harkness f. *cooperi* associated with many Pinaceae, and the false-truffle *Hysterangium crassum* (Tul. & Tul.) Fischer. None of the three species has been collected in the limber pine stand. The species present at Martin Creek are significant because both *Pseudotsuga menziesii* and *Pinus contorta* are not reported to occur in Humboldt County (Critchfield and Allenbaugh 1969; Cronquist et al. 1972). The presence of a Forest Service Guard Station nearby, built by the Civilian Conservation Corps in the 1930s, suggested that the trees might have been planted by the Corps and are exotic to Humboldt County.

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[1] Present address: 2 Canyon Shadows Rd., Lander, WY 82520, USA.

A search of the Humboldt Star, the local newspaper in Winnemuca, confirmed that the Corps had indeed planted the stand at Martin Creek. A short item in the May 20, 1936 edition headed “News of the CCC from Company 4706 Paradise Valley” with the subcaption “Tree Planting” reported that “Foreman Hickey has two hundred and fifty trees to plant. The trees are being planted on the other side of the summit, near the Martin Creek Guard Station.” Further searching of the newspaper failed to find any mention of the species or source of the seedlings. Most of the supplies used by the Corps were shipped from Fort Douglas in Salt Lake City, Utah which suggests a Rocky Mountain rather than a Cascade, or Sierra Nevada source for the seedlings. The Rocky Mountain origin of the seedlings is also supported by the identification of the Douglas-fir from Martin Creek, by Dr. Noel Holmgren (The New York Botanical Garden). He identified it as the Rocky Mountain form, *Pseudotsuga menziesii* var. *glauca* (Mayr) Franco. Out of the 250 seedlings planted by the Corps, only 18 Douglas-fir and five lodgepole pine survive in the stand producing truffles and false-truffles at Martin Creek. Reproduction has also been poor. One Douglas-fir seedling is present at Martin Creek and several lodgepole pine seedlings are present in a grassy seep below the stand. Other species were also planted by the Corps but have not yielded hypogeous fungi. Two large blue spruce, *Picea pungens* Engelm., and ponderosa pine, *Pinus ponderosa* Laws., planted next to the creek at the Martin Creek Guard Station remain. Two large blue spruces and one large white fir, *Abies concolor* (Gord. & Glend.) Lindl. ex Hildebr., grow adjacent to summer cabins on the creek just north of the Guard Station. Blue spruce planted by the Corps is also present at the Lamance Administrative site on Lamance Creek (Tina Graft, pers. com.), but has not been collected for hypogeous fungi.

The hypogeous fungi were undoubtedly introduced as fungal symbionts of ectomycorrhizae on roots of the seedlings. The distances to native stands of the trees are too great for rodent transport of inoculum in feces. The nearest lodgepole pine stands are the South Hills in southern Idaho, approximately

190 air miles to the east, or the Warner Mountains in northeastern California, approximately 140 miles to the west. The nearest Douglas-fir stand, the Owyhee Range in Idaho, is approximately 90 miles to the northeast.

The persistence of the mycelia of these fungi for 57 plus years is not surprising. Anecdotal evidence from production of the Perigord truffle, *Tuber melanosporum* Vitt., from inoculated trees suggests that the mycelium of these hypogeous fungi lives for decades. Truffle production starts three to seven years after planting inoculated hazels (*Corylus avellana* L.) and continues for 12 to 18 years (Hall and Brown 1989). Inoculated oaks begin producing 10 years after inoculation and may continue producing for 100 years (Hall and Brown 1989, Singer and Harris 1987). Better data on the longevity of the mycelia is needed for understanding the genetics of Great Basin populations of hypogeous fungi. The older the mycelium the greater the probability for accumulation of mutations and the evolution of new taxa. Some mycelia are estimated to be very old. Smith et al (1992) estimated the mycelium of the fungal root rot, *Armillaria bulbosa* (J. B. Barla) G. A. Kile & R. Watling, to be at least 1500 years old and to occupy a minimum of 15 ha. This fungus lives much longer than its hosts! A "fairy ring" formed in France by the saprobic fungus *Clitocybe geotropa* (Bull.) Quėl. is 600 m in diameter and is estimated to be 700 years old (Gregory 1982). The rings of the saprobe *Calocybe gambosum* (Fr.) Donk, estimated to be several centuries old, near Stonehenge, are large enough to show up well in aerial photographs (Ramsbottom 1953). Mycelia in the Great Basin may not be as large, or as old. Gregory (1982) states that tethered fairy rings, those formed by ectomycorrhizal fungi associated with a tree, "cannot extend indefinitely for decades or centuries like the free rings in grasslands." He may be underestimating the longevity of ectomycorrhizal mycelia, given the 57-year association of hypogeous fungi with their exotic hosts reported here and the anecdotal evidence that truffle mycelia can survive for 100 years.

Finally, collectors should be aware of the potential for exotic hypogeous fungi to occur wherever seedlings of ectomycorrhizal hosts have been planted in the Great Basin and adjacent Cordilleras.

MATERIALS AND METHODS

Methods of collection and study of the morphological and anatomical features are essentially those of Smith (Smith and Zeller, 1966). Herbarium names are abbreviated according to Holmgren, Holmgren, and Barnett (1990).

Location: Near Martin Creek Guard Station, 1.2 mi N of Hinkey Summit on Humboldt National Forest Route 084, 8.5 mi N of Forest boundary, Santa Rosa Mountains, 41°40.55' N lat., 117°32.30' W Long., elevation ca. 2171 m. The stand of Douglas-fir and lodgepole pine is located at the terminus of a small lava flow. The stand is fed by a wet seep and is surrounded by aspen, *Populus tremuloides* Michx., on three sides and has a thick ground cover of bracken, *Pteridium aquilinum* (L.) Kuhn, and western sweet-cicely, *Osmorhiza occidentalis* (Nutt.) Torr. The site is fenced and has been used to pasture horses and cows.

Voucher Collections: *Barssia oregonensis*, 10 Jul.1994. R. Fogel F4680, F4681 (MICH). *Geopora cooperi* f. *cooperi*, 6 Aug. 1993. R. Fogel F4500 (MICH). *Hysterangium crassum*, 14 Jul. 1995. R. Fogel F5054 (MICH). *Pinus contorta*, 14 Jul. 1995. R. Fogel s.n. (MICH, NY). *Pseudotsuga menziesii* var. *glauca*, 14 Jul. 1995. R. Fogel s.n. (MICH, NY)

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Tina Graft, Natural Resource Specialist, Humboldt National Forest, kindly provided information on stands of trees in the Santa Rosa Mountains and searched the Humboldt Star for information on the origin of the Martin Creek stand. Dr. Noel Holmgren, The New York Botanical Garden, kindly identified the trees. The survey of truffles and false-truffles is supported in part by National Science Foundation grants DEB 9400871. The generous assistance of Clark T. Rogerson is also gratefully acknowledged.

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MYCOTAXON

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MATERIALS FOR A HYPOGEOUS MYCOFLORA OF THE GREAT BASIN AND ADJACENT CORDILLERAS OF THE WESTERN UNITED STATES. VI: HYMENOGASTER RUBYENSIS, SP. NOV. (BASIDIOMYCOTA, CORTINARIACEAE)

Robert Fogel
University of Michigan Herbarium, North University Building,
Ann Arbor, Michigan 48109-1057, USA

Jack States[1]
Department of Botany, University of Wyoming, Laramie, Wyoming
82071, USA

ABSTRACT

A new species of *Hymenogaster*, *H. rubyensis,* associated with *Salix* in the Ruby Mountains, Nevada, United States, is described and illustrated.

Key Words: false-truffle, Nevada, sequestrate.

This is the sixth in a series containing materials for a hypogeous mycoflora of the Great Basin and adjacent Cordilleras (Fogel 1994, Fogel and Pacioni, 1989). The Great Basin, as defined by Cronquist et al. (1972), occupies an area of 714,854 square km. The vegetation in the Region contains many suitable ectomycorrhizal hosts for hypogeous fungi patchily distributed on isolated mountain ranges. The species composition of a specific stand reflects the interaction of environmental optima for species, soil factors, pre-glacial flora, extent of glacial advance, pluvial lake levels, and subsequent re-invasion from glacial refugia (Wells, 1983). Another significant factor affecting the presence of hypogeous fungi is the efficiency of mycophagous rodents, and perhaps insects, in spore dispersal.

Our survey of the Great Basin and adjacent Cordilleras has involved collecting in a large number of habitats. One of our favorite places to collect is the subalpine zone of the Ruby Mountains of northeastern Nevada. Large granite boulders separate the lush meadows filled with wildflowers and willow lined rivulets. Small ridges and north slopes sport stands of white bark pine (*Pinus albicaulis* Engelm.). The stands are usually open becoming

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[1] Address for correspondence: 2 Canyon Shadows Rd., Lander, WY 82520.

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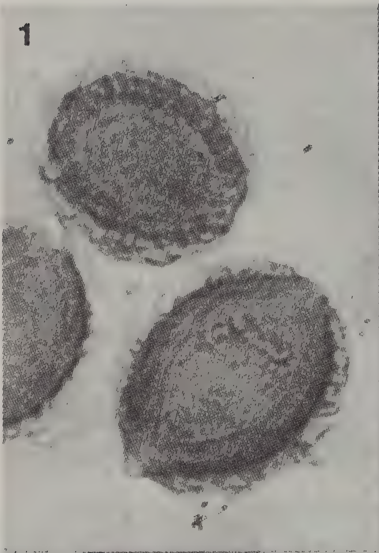

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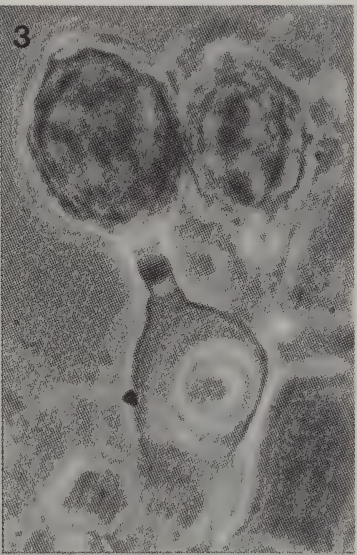

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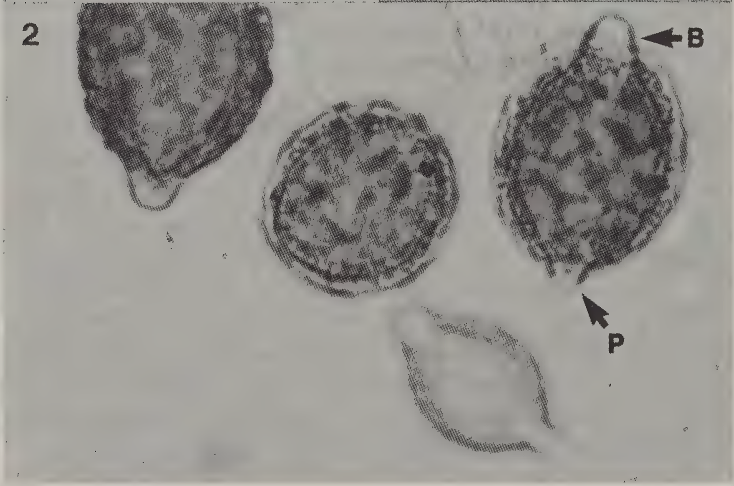

denser on protected slopes. We do not normally collect under willow because we have been disappointed many times, but on one trip the leaf litter under willows in the meadow was raked back to reveal a small *Hymenogaster*. We searched for the *Hymenogaster* on subsequent trips without success. We stopped looking when the number of hikers using the trail through the meadow increased dramatically in the nineties.

MATERIALS AND METHODS

Methods of collection and study of the morphological and anatomical features are essentially those of Smith (Smith and Zeller, 1966). Spores were measured in freehand sections mounted in Melzer's reagent. Lengths and widths of 20 basidiospores randomly selected from the single mature basidioma were measured for statistical comparisons. Herbarium names are abbreviated according to Holmgren, Holmgren, and Barnett (1990).

HYMENOGASTER RUBYENSIS Fogel & States, sp. nov. Figs. 1-3.

Basidiomata 7-120 mm in diam., subglobosa, alba. Gleba brunnea, loculis irregularibus. Peridium 70 µm crassum, hyphis hyalinus, devexum, usque ad 5 µm in diam. Trama 40-60 µm crassa, cellulis usque ad 60 x 35 µm. Basidia 22-23 x 10-11 µm subcylindrica ad cylindrica, hyalina, 2-spora. Sporae (13-)16-18(-20) x 14-15(-18) µm, ornamentation includens, L/W= 1.14, subglobosae, ornamentum verrucoso-rugoso usque ad 2 µm alto, apex late papillatus. Holotypus: USA, NEVADA, Elko County, 29 August 1983, Fogel F2703(MICH).

Etymology: After the Ruby Mountains, Nevada, the site of the collections.

Basidiomata 7-10 mm broad, subglobose, surface glabrous, white, some with light yellow stains on base. **Gleba** strong brown to deep brown, locules labyrinthiform, empty. Chemical tests on the peridium: KOH, deep brown; $FeSO_4$, green. KOH turning gleba almost black. Consistency soft to firm. **Odor** of green corn. **Columella** absent, attached by fine basal rhizomorphs.

Spores subglobose, (13-)16-18(-20) x (11-)14-15(-18 µm) including ornamentation, but not beak or pedicel, mean length 16.4 ± 1.6 µm, mean width 14.6 ± 1.4 µm, L/W 1.12, n = 20 spores; brown; enclosed in a wrinkled

Figs. 1-3. *Hymenogaster rubyensis*. **Fig. 1.** Basidiospores in Melzer's reagent showing the thick spore wall in medial section, X1600. **Fig. 2.** Basidiospores in Melzer's reagent showing the loose utricle covering the spores, apical beak (B), and pedicel (P), X1600. **Fig. 3.** Two-spored basidium in Melzer's reagent, X1600, phase contrast.

utricle, ridges 1.5-2 µm high, spore apex papillate, beak 1-2 x 3-5 µm, obscured in mature spores by utricle, wall < 1 µm thick; pedicel tapered, lighter than spore body, 1-2 x 1-2 µm. **Basidia** subcylindrical to cylindrical, 22-23 x 10-11 µm; 2-spored, hyaline, thin-walled; sterigmata straight, tapered, 3 x 4 µm; not clamped at base. Basidioles subcylindrical, 15 x 10 µm, hyaline, thin-walled. Subhymenium composed of hyaline, thin-walled cells up to 15 x 10 µm. **Trama** mediostratum 40-60 µm wide, composed of hyaline, 4-5 µm broad, interwoven hyphae, cells inflated up to 60 x 35 µm, clamps absent. **Peridium** 70 µm thick, composed of periclinal, appressed, hyaline, thin-walled hyphae 3-5 µm broad, clamps absent. Not reviving well in Melzer's reagent or KOH.

Probable mycorrhizal host: subalpine *Salix* sp.

Phenology and distribution: Late August in Ruby Mountains, Nevada.

Collections examined: USA, NEVADA, Elko County, 29 August 1983, Fogel F2698 (MICH: paratype), F2703 (MICH: Holotype).

Notes: Differs from *H. minimus* Zeller, another species associated with willow, in shape and size of basidia, sterigmata length, and spore wall thickness. Differs from *H. glacialis* Cazares & Trappe, another willow associate, in having two-spored rather than 4-spored basidia, inflated cells in the mediostratum, persistent, single-layered peridium and smaller length:width ratio (1.12-1.14 vs. 1.18-1.69).

ACKNOWLEDGMENTS

This study was supported in part by grants from the National Science Foundation (BSR 90-24572, DEB 94-00871). The generous assistance of Clark T. Rogerson is also gratefully acknowledged.

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Figs. 1-3. *Hymenogaster rubyensis*. **Fig. 1.** Basidiospores in Melzer's reagent showing the thick spore wall in medial section, X1600. **Fig. 2.** Basidiospores in Melzer's reagent showing the loose utricle covering the spores, apical beak (B), and pedicel (P), X1600. **Fig. 3.** Two-spored basidium in Melzer's reagent, X1600, phase contrast.

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SMUT FUNGI (USTILAGINOMYCETES) OF SORGHUM (GRAMINEAE) WITH SPECIAL REGARD TO AUSTRALASIA

Kálmán Vánky[1] and Roger G. Shivas[2]

[1] Herbarium Ustilaginales Vánky (HUV), Gabriel-Biel-Str. 5,
D-72076 Tübingen, Germany. e-mail: VANKY.K@cityinfonetz.de

[2] Plant Pathology Herbarium (BRIP), Department of Primary Industries,
80 Meiers Road, Indooroopilly, Queensland 4068, Australia.
e-mail: shivasr@dpi.qld.gov.au

Key words: new species, new combinations, synonyms, *Macalpinomyces ewartii*, *Sporisorium australasiaticum*, *S. ryleyi*, *S. wynaadense*.

ABSTRACT

The smut fungi of *Sorghum* are revised. Of the 21 names 10 are recognised as valid species. Of these, four are present in Australasia including two endemic species. Two additional, new species from Australasia are proposed: *Sporisorium australasiaticum* and *S. ryleyi*. *Sporisorium wynaadense* (comb. nov.) is new to Australasia. Two further new combinations are proposed: *Sporisorium transvaalense* (from South Africa) and *Macalpinomyces ewartii*. *Sorosporium simii* is a synonym of *Sporisorium reilianum*. A key to the smut fungi of *Sorghum* is given.

INTRODUCTION

Sorghum Moench, with c. 20 species, belongs to the subfam. Panicoideae, tribe Andropogoneae, subtribe Sorghinae (Clayton & Renvoize, 1986:339). In Australia, Simon (1993) recognised 23 species.

On *Sorghum* at least 21 smut fungi have been described. Of these, we accept ten species: **1**. *Macalpinomyces ewartii* (McAlpine) Vánky & R. G. Shivas (based on *Ustilago ewartii*, see below), **2**. *Sporisorium cruentum* (Kühn) Vánky (based on *Ustilago cruenta*), **3**. *Sporisorium ehrenbergii* (Kühn) Vánky (based on *Sorosporium ehrenbergii*), **4**. *Sporisorium reilianum* (Kühn) Langdon & Fullerton (based on *Ustilago reiliana*), **5**. *Sporisorium sorghi* Ehrenberg ex Link,

6. *Sporisorium transvaalense* (Zundel) Vánky (based on *Sphacelotheca transvaalensis*, see below), **7**. *Sporisorium wynaadense* (Sundaram) Vánky & R. G. Shivas (based on *Ustilago wynaadensis*, see below), **8**. *Ustilago bulgarica* Bubák, **9**. *U. kenjiana* S. Ito, and **10**. *U. porosa* Langdon.

Eleven names are considered to be taxonomic synonyms: **1**. *Sorosporium andropogonis-sorghi* S. Ito (= *Sporisorium ehrenbergii*), **2**. *Sorosporium ehrenbergii* Kühn var. *grandiglobosum* (Uppal & Patel) Thirum. & Neerg. (= cf. *Sporisorium ehrenbergii*), **3**. *Sorosporium simii* Pole-Evans (= *Sporisorium reilianum*, comp. Vánky, below), **4**. *Sphacelotheca holci* H. J. Jackson (= *Sporisorium cruentum*, comp. G. W. Fischer, 1953:134), **5**. *Sphacelotheca sorghicola* (Speg.) Zundel (based on *Ustilago sorghicola*, = *Sporisorium sorghi*, comp. Ling, 1953:333), **6**. *Tilletia sorghi-vulgaris* L.-R. & C. Tul. (= *Sporisorium sorghi*, comp. Vánky, 1994:206), **7**. *Tolyposporium filiferum* Busse (= *Sporisorium ehrenbergii* (Kühn) Vánky, comp. Vánky, 1990:270), **8**. *Tolyposporium volkensii* Henn. (= *Cerebella sorghi-vulgaris* Subraman., mitosporic fungus, comp. Mason, 1926:286), **9**. *U. holci-sorghi* Rivolta, nomen dubium (= *Sporisorium reilianum*, comp. Vánky, 1994:204), **10**. *U. sorghi* Pass. (= *Sporisorium cruentum*, comp. Vánky, 1994:200), **11**. *U. sorghi-stipoidei* Ling (= *U. ewartii*, comp. Vánky, 1997:153).

Of the ten recognised smut fungi on *Sorghum*, four species are known in Australia: **1**. *Sporisorium reilianum* (Kühn) Langdon & Fullerton, 1978:451, type on *Sorghum bicolor* (L.) Moench, Egypt, **2**. *S. sorghi* Ehrenberg ex Link, 1825:86, neotype on *Sorghum bicolor* (L.) Moench, Egypt, **3**. *Macalpinomyces ewartii* (McAlpine) Vánky & R. G. Shivas (see below), type on *Sorghum stipoideum* (Ewart & White) C. Gardner & C. E. Hubb., Australia, and **4**. *U. porosa* Langdon, 1962:48, type on *Sorghum australiense* Garber & Snyder, Australia. The two latter species are endemic to Australia. *Sporisorium wynaadense*, collected on *Sorghum leiocladum*, is new to Australia. Two further smut fungi are described as new species:

Sporisorium australasiaticum Vánky & R. G. Shivas, **sp. nov.**

Typus in matrice *Sorghum nitidum* (Vahl) Pers. and its forma *aristatum* C. E. Hubb., Papua New Guinea, Central Province, cca. 57 km E urbe Port Moresby, Sogeri Plateau, prope Sirinumu Dam, 9°28'25" S, 147°26'58" E, alt. cca. 600 m.s.m., 21.III.1998, leg. R. G. Shivas, C. & K. Vánky. Holotypus in Herbario Ustil. Vánky, HUV 19.572, isotypi in BRIP 26696, BPI, et in Vánky, Ust. exs. no. 1123. Paratypi in matrice *Sorghum leiocladum* (Hackel) C. E. Hubb., Australia, Queensland, Killarney, 6.I.1966, leg. R. A. Fullerton, BRIP 6485 (as *Sporisorium sorghi*); Queensland, Hirstglen, 15.IX.1977, leg. M. J. Ryley, BRIP 15386, HUV 19502.

Sori in spiculis organa floralia interna destruentes, involucris floralibus extimis plus-minus absconditi, globoidei usque ovoidei, 1–1,5 x 1–2 mm, primo peridio crasso, brunneo cooperti, quo irregulariter rupto massam pulveream sporarum et cellularum sterilium ostendentes, columellam centralem, simplicem, nonnunquam

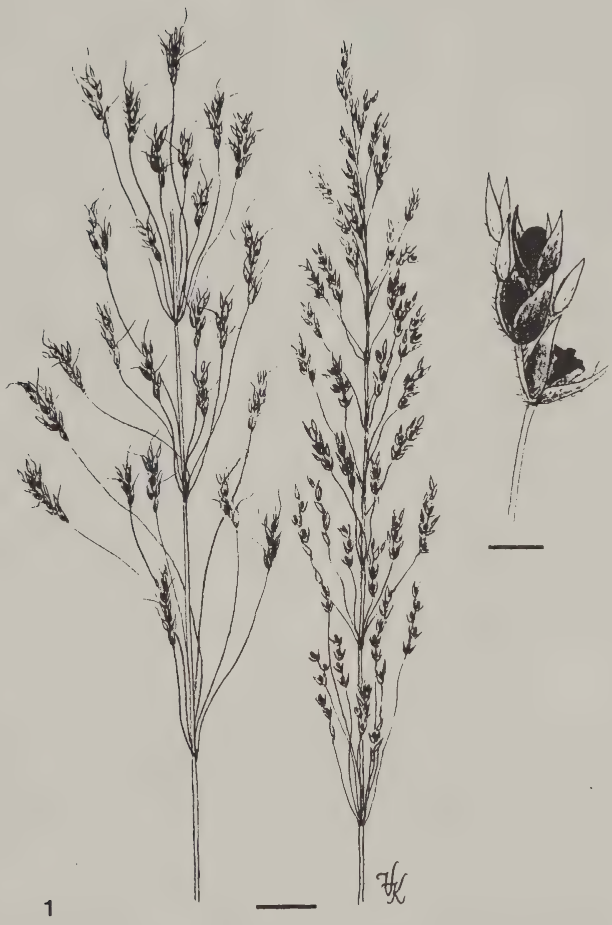


Fig. 1. Sori of *Sporisorium australasiaticum* Vánky & R. G. Shivas on *Sorghum nitidum* (Vahl) Pers. forma *aristatum* C. E. Hubb. (type). Habit (middle) and three sori (enlarged, right). Part of a healthy inflorescence (left).
Bars = 1 cm for the habit, and 2 mm for the sori.

ramulis brevibus apicalibus instructam, circumdantes. Raro, sori etiam racemum unum vel racemos nonnullos vel ramos cunctos inflorescentiae eiusdem occupantes, tum cylindrici, usque 30 mm longi. *Sporae* maturae singulae, subglobosae, ovoideae usque late ellipsoidales, 7,5–9,5 x 8–11 µm, flavidobrunneae; pariete aequaliter crasso (cca. 0,5 µm), cum area una pallida, rotunda, 1–1,5 µm diametro, verisimiliter poro germinali. Superficies sporarum in LM subtiliter verruculosa, imago obliqua sporarum levis usque valde subtiliter serrulata, in SEM subtiliter echinulata, inter spinas dense, subtiliter verruculosa. *Cellulae steriles* in catervis parvis, cellulae singulae forma et magnitudine variae, plerumque irregulares cum lateribus contactis deplanatis, 6–16 µm longae, hyalinae; pariete aequali, cca. 0,5 µm crasso, levi.

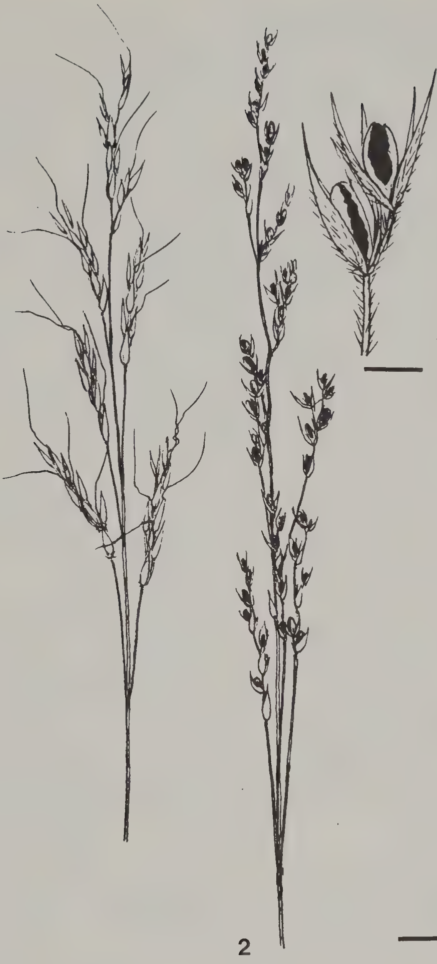
Sori (Fig. 1) in the spikelets destroying the inner floral organs, more or less hidden by the outermost floral envelopes, globoid to ovoid, 1–1·5 x 1–2 mm, first covered by a thick, brown peridium which ruptures irregularly disclosing the dark brown, powdery mass of spores and sterile cells surrounding a simple, central columella sometimes with short, apical branches. Rarely, the sori may comprise one or several racemes or whole inflorescence branches, then cylindrical, up to 30 mm long. *Spores* (Figs. 4, 5) when mature single, subglobose, ovoid to broadly ellipsoidal, 7·5–9·5 x 8–11 µm, yellowish-brown; wall evenly thick (c. 0·5 µm), with a paler, rounded area of 1–1·5 µm diameter, probably germ pore. Spore surface in LM finely verruculose, spore profile smooth to very finely serrulate, in SEM finely echinulate, between the spines densely, finely verruculose. *Sterile cells* (Figs. 4, 5) in small groups, single cells variable in shape and size, usually irregular with flattened contact sides, 6–16 µm long, hyaline; wall even, c. 0·5 µm thick, smooth.

On *Sorghum leiocladum* (Hackel) C. E. Hubb., Australia, and *S. nitidum* (Vahl) Pers., Papua New Guinea.

Sporisorium australasiaticum differs from *S. cruentum* by the rather persistent peridium, by slightly larger spores and by the presence of germ pores. In *S. cruentum* the peridium is early dehiscent, the spores are 7·5–10 µm long and apparently without germ pores. *S. australasiaticum* differs from *S. sorghi* and *S. ryleyi* by its larger spores and by the presence of germ pores (see also the key below).

Sporisorium ryleyi Vánky & R. G. Shivas, **sp. nov.**

Typus in matrice *Sorghum leiocladum* (Hackel) C. E. Hubb., Australia, Queensland, cca. 150 km NW Brisbane, Bunya Mts., Maidenwell, 26°55'07" S, 151°47'58" E, alt. cca. 560 m.s.m., 13.XII.2000, leg. R. G. Shivas, M. J. Ryley & J. R. Dean. Holotypus in BRIP 27719, isotypus in Herbario Ustil. Vánky, HUV 19577. Paratypi in matrice *Sorghum leiocladum* (Hackel) C. E. Hubb., Australia, Queensland, cca. 150 km NW Brisbane, Bunya Mts., Maidenwell, 26°52'48" S, 151°47'13" E, alt. cca. 560 m.s.m., 13.XII.2000, leg. R. G. Shivas, M. J. Ryley & J. R. Dean, BRIP 27641, et in matrice *Sorghum plumosum* (R. Br.) P. Beauv., Australia, Queensland, cca. 10 km E Mareeba, 16°59'32" S, 145°30'40" E, alt. cca. 380 m.s.m., 4.IV.1998, leg. C. & K. Vánky, HUV 19611, BRIP 27749, BPI.



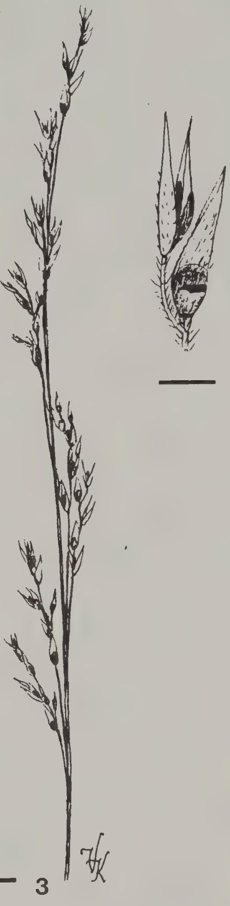


Fig. 2. Sori of *Sporisorium ryleyi* Vánky & R. G. Shivas on *Sorghum leiocladum* (Hack.) C. E. Hubb. (type). Habit, and two sori (enlarged). Part of a healthy inflorescence (left).

Fig. 3. Sori of *Sporisorium wynaadense* (Sundaram) Vánky & R. G. Shivas on *Sorghum leiocladum*, Australia, Queensland, Bunya Mts., 13.XII.2000, R. G. Shivas, M. J. Ryley & J. R. Dean (HUV 19541). Habit, and two sori (enlarged).

Bars = 1 cm for the habit, and 2 mm for the sori.

Sori in spiculis partes internas florum, raro etiam partem basalem glumarum destruentes, ovoidei usque longe ellipsoidalales, 1–1,5 x 1,5–4 mm, glumis plusminus absconditi, primo peridio crasso, brunneo cooperti, quo irregulariter rupto massam atrobrunneam, pulveream sporarum et cellularum sterilium, columellam centralem, in longitudine sori dispositam circumdantium ostendentes. *Sporae* in statu maturo singulae, globosae, subglobosae, ellipsoidales, raro ovoideae vel elongatae, 4–5,5 x 4,5–6,5(–7) µm, olivaceobrunneae; pariete aequaliter crasso (cca. 0,5 µm), subtiliter verruculoso, imago obliqua sporae levis. *Cellulae steriles* plerumque in catervis parvis, raro singulae, forma et magnitudine variae, subglobosae usque irregulares cum lateribus contactis deplanatis, 5–12 µm longae, hyalinae; pariete aequali, 0,5–0,8 µm crasso, levi.

Sori (Fig. 2) in the spikelets destroying the inner floral organs, rarely also the basal part of the glumes, ovoid to long ellipsoidal, 1–1·5 x 1·5–4 mm, more or less hidden by the glumes, first covered by a thick, brown peridium which ruptures irregularly disclosing the dark brown, powdery mass of spores and sterile cells surrounding a thick, simple, central columella of the length of the sorus. *Spores* (Figs. 6, 7) when mature single, globose, subglobose, ellipsoidal, rarely ovoid or elongated, 4–5·5 x 4·5–6·5(–7) µm, olivaceous-brown; wall evenly thick (c. 0·5 µm), finely verruculose, spore profile smooth. *Sterile cells* (Figs. 6, 7) usually in small groups, single cells variable in shape and size, subglobose to usually irregular with flattened contact sides, 5–12 µm long, hyaline; wall even, 0·5–0·8 µm thick, smooth.

On *Sorghum leiocladum* (Hackel) C. E. Hubb., and *S. plumosum* (R. Br.) P. Beauv.; known from several collections in Australia.

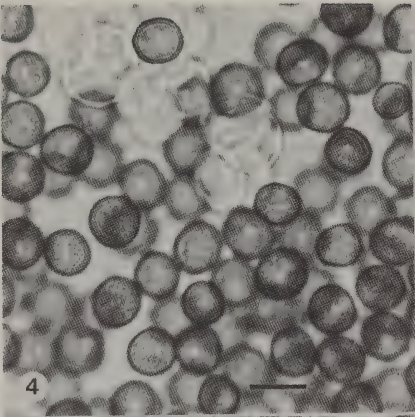
Etymology: This species is named after Dr. Malcolm J. Ryley, plant pathologist and collector, whose knowledge of *Sorghum* diseases lead to the discovery of this smut fungus.

Sporisorium ryleyi differs from all known smut fungi of *Sorghum* by the small size of its spores. In its appearance it is closest to *S. sorghi* Ehrenberg ex Link which has larger spores that measure 5·5–7 x 5·5–8(–8·5) µm.

Figs. 4, 5. Spores and sterile cells of *Sporisorium australasiaticum* Vánky & R. G. Shivas on *Sorghum nitidum* (Vahl) Pers., in LM and in SEM (type). Note the typical light, rounded germ pores of the spores on the LM picture.

Figs. 6, 7. Spores and sterile cells of *Sporisorium ryleyi* Vánky & R. G. Shivas on *Sorghum leiocladum* (Hack.) C. E. Hubb. in LM and in SEM (type).

Figs. 8, 9. Spores and sterile cells of *Sporisorium wynaadense* (Sundaram) Vánky & R. G. Shivas on *Sorghum leiocladum*, in LM and in SEM. Australia, Queensland, Bunya Mts., 13.XII.2000, R. G. Shivas, M. J. Ryley & J. R. Dean (HUV 19541). Bars = 10 µm.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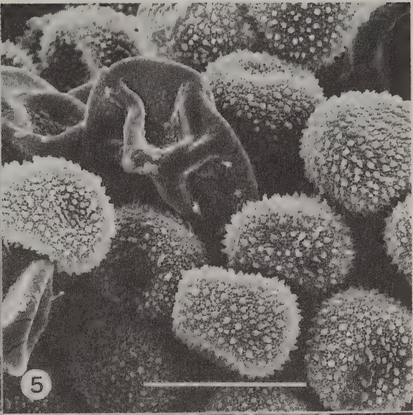
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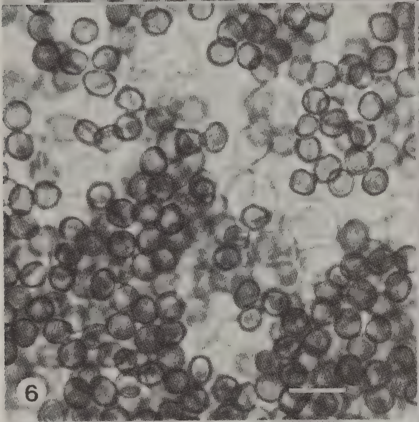
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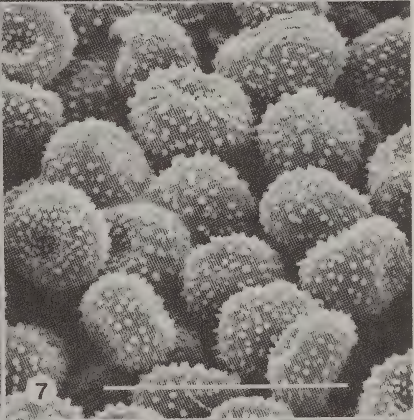
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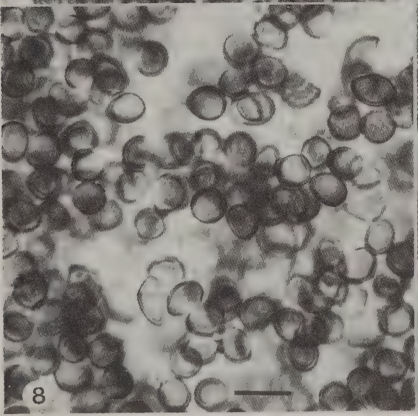
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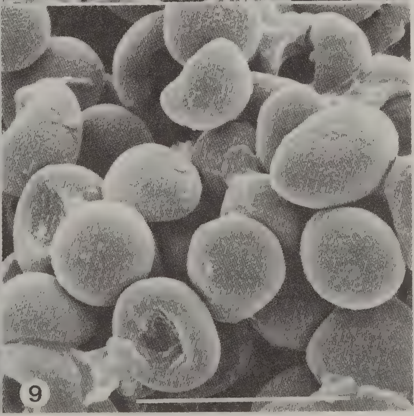
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Ustilago wynaadensis Sundaram shows characters of a *Sporisorium* and is transferred into this genus:

Sporisorium wynaadense (Sundaram) Vánky & R. G. Shivas, **comb. nov.** Basionym: *Ustilago wynaadensis* Sundaram, Sci. & Cult. 30:604, 1964. — Type on *Sorghum nitidum* (Vahl) Pers., India, Wynaad Province, Mavanahalli, 30.IX.1955, leg. N. Krishnawany. Isotypes in IMI 135010, HUV 17396.

Sori (Fig. 3) destroying the inner part of the spikelets, transforming them into a 2–4 mm long, ellipsoidal or conically acuminate bodies, more or less hidden by the glumes, first covered by a peridium which ruptures disclosing the brown, powdery mass of spores and sterile cells surrounding a short, simple, central columella. Furthermore, the fungus usually destroys also the basal part of the glumes appearing first as grey swellings similar to those produced by *Ustilago bullata* Berk. *Spores* (Figs. 8, 9) when mature single, variable in shape and size, subglobose, ellipsoidal or elongated, sometimes lacrimiform, often slightly irregular with a flattened side, 4·5–7 x 6–9 µm, olivaceous-brown, paler on one side; wall unevenly thick, c. 0·5–0·6 µm on the darker side, c. 0·2–0·3 µm on the pale side, smooth. *Spore germination* of freshly collected spores from *Sorghum leiocladum* (Fig. 16; on potato-dextrose-agar, at room temp., in one day) resulted in 4-celled, cylindrical basidia of 3·5–5 x 25–40 µm, on which laterally and terminally ovoid to ellipsoidal basidiospores are produced measuring 2-4 x 5-11 µm. *Sterile cells* (Figs. 8, 9) single, in pairs or in small groups, single cells about the size of or larger than the spores, globose to irregular, 6–14 µm long, hyaline; wall thin, c. 0·5 µm, smooth.

On *Sorghum leiocladum* (Hackel) C. E. Hubb., and *S. nitidum* (Vahl) Pers.; Australia, India.

Regarding spore morphology, *Sporisorium wynaadense* is close to *Ustilago porosa* Langdon. In both species the spores are smooth and darker on one side. However, *U. porosa* destroys the whole inflorescence, leaving behind a typical, porose structure of host tissues. Furthermore, *U. porosa* lacks sterile cells and has somewhat larger spores (6–10·5 µm long) than *S. wynaadense*.

Ustilago ewartii McAlpine shows characters of the genus *Macalpinomyces* and it is transferred into this genus:

Macalpinomyces ewartii (McAlpine) Vánky & R. G. Shivas, **comb. nov.** Basionym: *Ustilago ewartii* McAlpine, Proc. Linn. Soc. New South Wales 36:45, 1911(1912). — Type on *Sarga stipoidea* Ewart & White (= *Sorghum stipoideum* (Ewart & White) C. Gardner & C. E. Hubb.), Australia, Western Australia, Napier, Broome Bay, 22.V.1910, A. J. Ewart, MEL 1055129!

Sori (Fig. 10) in considerably swollen ovaries affecting a few in the inflorescence, obovoid with a narrowing basal part and a shortly acute tip with remnants of the styles, more rarely lemon-shaped, 4–10 x 8–15 mm, covered by a first green, later brown, thick membrane which ruptures at maturity disclosing the

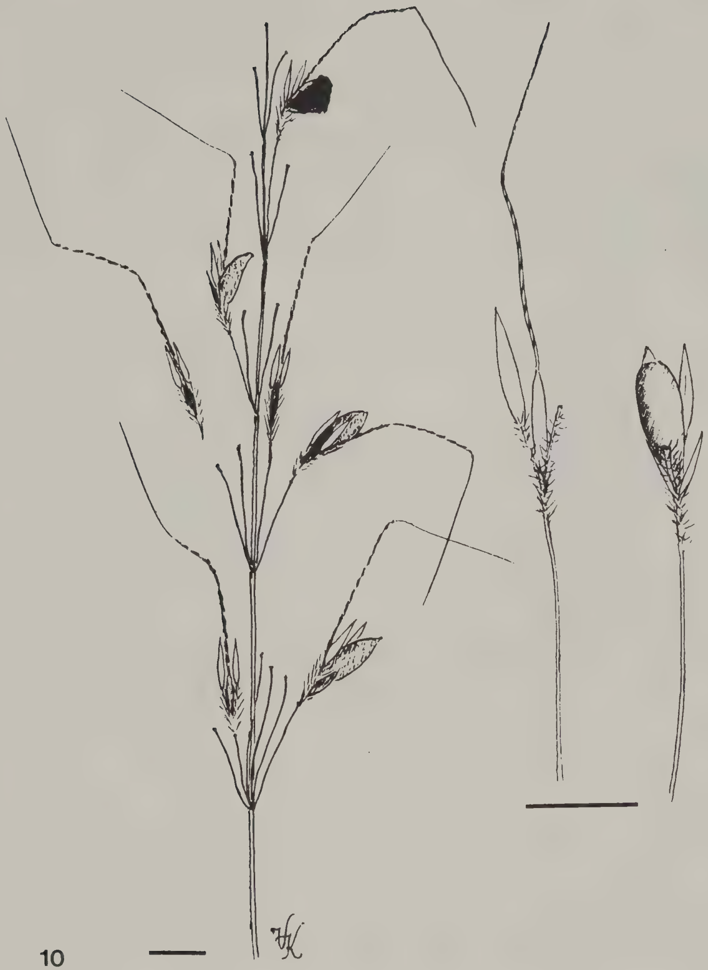


Fig. 10. Sori of *Macalpinomyces ewartii* (McAlpine) Vánky & R. G. Shivas on *Sorghum stipoideum* (Ewart & J. White) C. Gardner & C. E. Hubb., Australia, NT, 125 km S. Darwin, 13.III.2000, R. G. Shivas, I. T. Riley, C. & K. Vánky (Vánky, Ust. exs. no. 1094). Habit (left), healthy pair of spikelets (enlarged, middle) and a sorus (enlarged, right). Bars = 1 cm.

brown, powdery mass of spores intermixed with groups of sterile cells. *Spores* (Figs. 12, 13) globose, subglobose, ellipsoidal, variable in size, 9–14·5 x 9–15 µm, yellowish-brown; wall evenly thick, provided with densely situated, 0·5–1·5 µm high, conical spines. *Spore germination* [in water, McAlpine, 1911 (1912):46] results in septate basidia of variable length composed of numerous cells producing laterally and terminally 3–6 µm long, fusiform basidiospores often in chains of three or more. *Sterile cells* (Fig. 12) in large, loose, irregular groups, single cells globose, ovoid, ellipsoidal to slightly irregular, 8–13 x 8–16 µm, hyaline; wall even, 0·5–0·8 µm thick, smooth, content homogenous.

On *Sorghum interjectum* Lazarides, *S. intrans* F. Muell. ex Benth., *S. plumosum* (R. Br.) Beauv., *S. stipoideum* (Ewart & White) C. Gardner & C. E. Hubb. (*Sarga stipoidea* Ewart & White), *S. timorense* (Kunth) Buse; Australia.

The study of *Sphacelotheca transvaalensis* Zundel showed that it belongs to the genus *Sporisorium*:

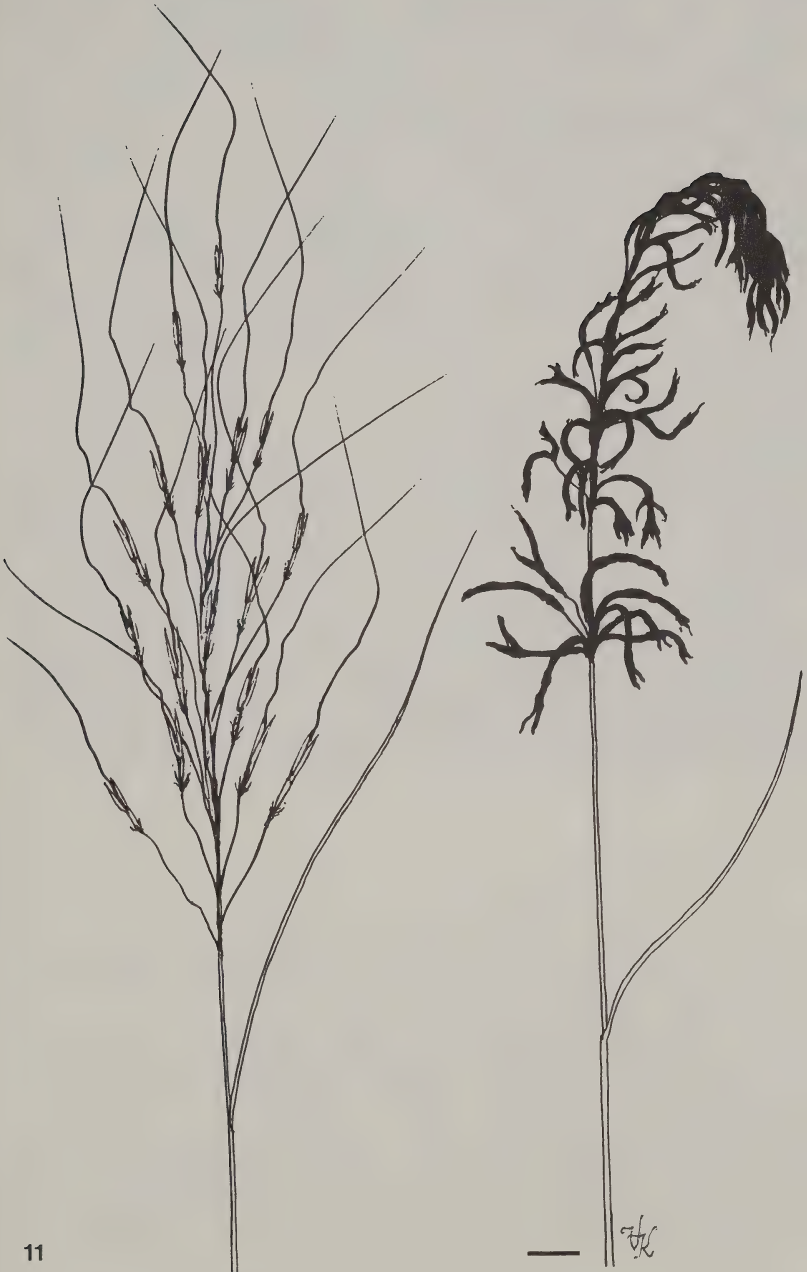
Sporisorium transvaalense (Zundel) Vánky, **comb. nov.**

Basionym: *Sphacelotheca transvaalensis* Zundel, Mycologia 22:139, 1930. — Type on "*Andropogon* sp. (*Sorghum* sp.)" (= *Sorghum versicolor* Anderss.), Rep. of South Africa, Transvaal, Pretoria, Onderstepoort, 23.I.1919, A. O. D. Mogg. Holotype in PREM 17047, isotypes in BPI 195093, HUV 17937!

Sori in the sessile spikelets, ovoid, cylindrical or irregular, 2–3 x 4–10 mm, one or several in a spikelet, destroying the inner floral organs, usually leaving the outermost floral envelopes intact, first covered by a thick, brown peridium which ruptures and flakes away disclosing the dark brown, semiagglutinated to powdery mass of spores, groups of sterile cells and a much branching, "root-like" columella of the length of the sorus. Rarely, the sori may comprise several spikelets. *Spores* when mature single, globose, subglobose, ovoid, broadly ellipsoidal or slightly subpolyhedrally irregular, 9–12 x 9–13 µm, yellowish-brown; wall evenly thick, 0·5–1 µm, finely, densely verrucose-echinulate, spore profile smooth to finely rough. *Sterile cells* in small, irregular groups, single cells variable in shape and size, ovoid, subcuneiform, usually irregular with one or several flattened sides, 5–13(–16) x 5–16(–20) µm, when young hyaline, with granular content, later pale yellowish-brown, empty; wall 0·5–1 µm thick, smooth.

On *Sorghum versicolor* Anderss.; S. Africa (Rep. of South Africa, Zimbabwe).

Fig. 11. Sori of *Ustilago porosa* Langdon on *Sorghum stipoideum* (Ewart & J. White) C. Gardner & C. E. Hubb., Australia, Kununurra, Molly Springs, 25.II.1996, C. & K. Vánky (HUV 17731). Habit (right), healthy inflorescence (left). Bar = 1 cm.



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Sorosporium simii **is** ***Sporisorium reilianum.***

The study of ***Sorosporium simii*** Pole-Evans, 1916:543 [type on "*Sorghum halepense*" (L.) Pers.(= *S. verticilliflorum* (Steud.) Stapf, teste Doidge, 1950:380, = *S. bicolor* (L.) Moench subsp. *arundinaceum* (Desv.) De Wet & Harlan), South Africa, Natal, Maritzburg, 23.II.1915, J. M. Sim, PREM 8978!] revealed that it is identical with and a synonym of ***Sporisorium reilianum*** (Kühn) Langdon & Fullerton. (Synonymy stated by Vánky).

Ustilago porosa Langdon, 1962:48.

Type on *Sorghum australiense* Garber & Snyder, Australia, Northern Territory, Antony Lagoon, 15.V.1947, S. T. Blake, BRIP 7803, isotypes in IMI 43752, HUV 17799.

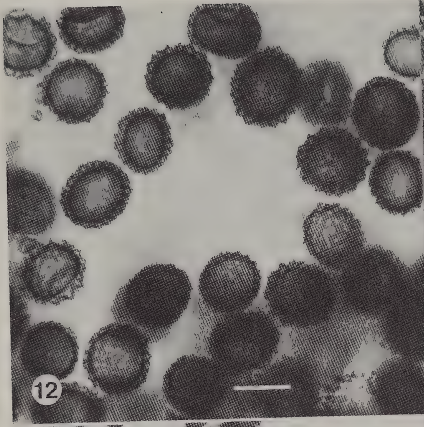
Sori (Fig. 11) destroying the whole inflorescence leaving intact the axis and primary branches of the inflorescence, transforming the partial inflorescences into irregular, cylindrical, acuminate, rarely branching, dark brown, porose bodies measuring 1–2 x 10–20 mm, filled by a dusty mass of spores. After the spores are scattered a grey, porose structure remains behind composed of remnants of host tissues, and a long, central, irregular, flagelliform columella. *Spores* (Figs. 14, 15) rather variable in shape and size, globose, subglobose, ellipsoidal, elongate, slightly irregular, rarely acuminate, 5–6·5 x 5·5–8(–9) µm, olivaceous-brown, darker on one side; wall in LM smooth, on the dark side c. 0·7 µm thick, much thinner (c. 0·2 µm) on the paler side; in SEM the surface is rough. *Sterile cells* absent.

On *Sorghum amplum* Lazarides, *S. australiense* Garber & Snyder, *S. intrans* F. Muell. ex Benth., *S. plumosum* (R. Br.) Beauv., *S. stipoideum* (Ewart & White) C. Gardner & C. E. Hubb., *S. timorense* (Kunth) Buse; Australia.

Figs. 12, 13. Spores of of *Macalpinomyces ewartii* (McAlpine) Vánky & R. G. Shivas on *Sorghum stipoideum* (Ewart & J. White) C. Gardner & C. E. Hubb., in LM and in SEM (Vánky, Ust. exs. no. 1094).

Figs. 14, 15. Spores of *Ustilago porosa* Langdon on *Sorghum stipoideum* (Ewart & White) C. Gardner & C. E. Hubb., in LM and in SEM, Australia, WA, Kununurra, 4.III.1992, R. G. Shivas (HUV 17438).

Fig. 16. Germinating spores of *Sporisorium wynaadense* (Sundaram) Vánky & R. G. Shivas from *Sorghum leiocladum*, Australia, Queensland, Bunya Mts., 13.XII.2000, R. G. Shivas, M. J. Ryley & J. R. Dean (on potato-dextrose-agar, at room temp., in one day). Bars = 10 µm.



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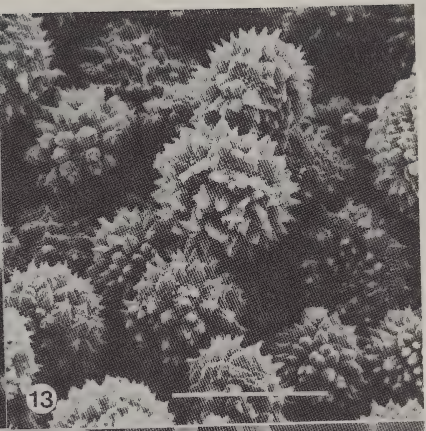

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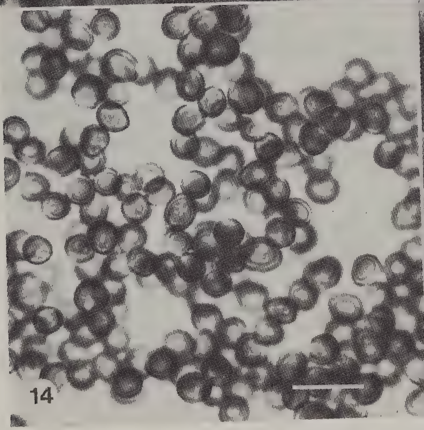

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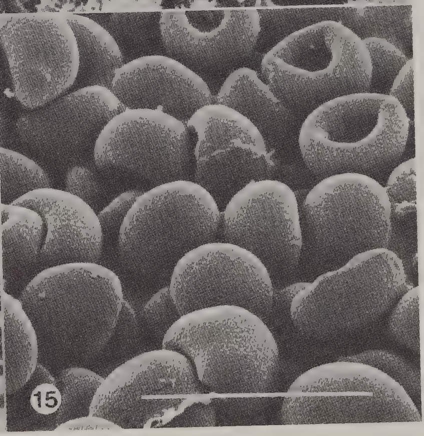

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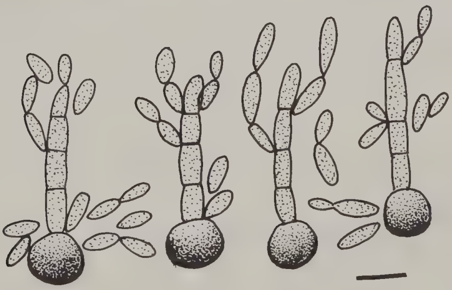

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Key to the smut fungi of *Sorghum*
(*U.* = *Ustilago*, *S.* = *Sporisorium*)

1. Spores darker on one side....................2
– Spores not darker on one side....................3
2. Sori in the whole inflorescence, sterile cells absent....................*U. porosa*
– Sori in the spikelets, sterile cells present....................*S. wynaadense*
3. Sori in the whole inflorescence....................*S. reilianum*
– Sori in the ovaries or spikelets....................4
4. Sori in considerably hypertrophied ovaries....................5
– Sori in the spikelets....................6
5. Sori cylindrical. Spores in permanent balls. Sterile cells absent... *S. ehrenbergii*
– Sori obovoid. Spores single. Sterile cells present ....*Macalpinomyces ewartii*
6. Sori of polycystic structure....................*U. bulgarica*
– Sori not of polycystic structure....................7
7. Columella absent. Spores 4–7·5 µm long, verruculose....................*U. kenjiana*
– Columella/ae present....................8
8. Columellae several, much branching. Spores 9–13 µm long.....*S. transvaalense*
– Columella one, simple or with short, apical branches. Spores smaller.............9
9. Peridium thin, early dehiscent. Spores 7·5–10 µm long, verrucose-echinulate....................*S. cruentum*
– Peridium thick, rather persistent. Spores finely verruculose....................10
10. Spores 8–11 µm long, with a light germ pore....................*S. australasiaticum*
– Spores smaller, without evident germ pores....................11
11. Spores 5–8·5 µm long....................*S. sorghi*
– Spores 4·5–6·5(–7) µm long....................*S. ryleyi*

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The authors are grateful to Dr. S. Tóth (Gödöllő, Hungary) for providing the Latin descriptions, to the late Professor Zambettakis (PC) for the isotype of *Ustilago wynaadensis* to the senior author, and to the Directors and Curators of AD, DAR, IMI, MEL, PERTH and VPRI for loans of specimens.

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NEW SPECIES AND NEW RECORDS IN THE LICHEN FAMILY PARMELIACEAE (ASCOMYCOTINA) FROM INDIA

P. K. DIVAKAR & D. K. UPRETI
Lichen Laboratory, National Botanical Research Institute, Rana Pratap Marg, Lucknow-226 006, Uttar Pradesh, India
email: sanjeeva_n@yahoo.com

JOHN A. ELIX
Department of Chemistry, The Faculties, Australian National University, Canberra, ACT 0200, Australia
email: John.Elix@anu.edu.au

ABSTRACT : *Hypotrachyna neosingularis, Melanelia gomukhensis, Myelochroa macrogalbinica* and *M. upretii* from India are described as new to science. Two additional species of Parmeliaceae are reported for the first time from India.

KEY WORDS: *Hypotrachyna neosingularis, Melanelia gomukhensis, Myelochroa macrogalbinica, M. upretii, Parmotrema, Relicinopsis*

The lichen flora of the Indian subcontinent has been investigated intensively over the past 40 years (see Awasthi 2000). However, the lichens of some inaccessible regions as well as some difficult genera and species complexes remain to be studied. We have now undertaken a detailed survey of recent collections of the family Parmeliaceae from India, culminating in our describing four species new to science and two new records for the country. Chemical constituents were identified by thin layer chromatography (Culberson 1972; Culberson & Johnson 1982; Elix & Ernst-Russell 1993), high performance liquid chromatography (Feige *et al.* 1993; Elix *et al.* 1997) and comparison with authentic samples.

Hypotrachyna neosingularis Divakar, Upreti & Elix, sp. nov. Fig. 1

Thallus ut in *Hypotrachyna singularis* sed lobulis rotundibus, sporis minoribus et acidum lichesterinicum et acidum protolichesterinicum continente differt.

Type: INDIA. Sikkim: Gangtok, on bark, *K. P. Srivastava s.n.*, July 1959; holo: LWG.

Thallus corticolous, foliose, loosely adnate to adnate, coriaceous, to 8 cm wide. *Lobes* imbricate, sublinear to irregular, 3-5 mm wide; margins eciliate, lobulate; lobulae rounded, marginal and laminal, dense in thallus centre, 0.2-1.0 mm wide. *Upper surface* grey, becoming grey-brown with age, flat or buckled, smooth, shiny, emaculate, ±irregularly cracked; isidia, soredia and pustules absent. *Medulla* white. *Lower surface* black to the margin; rhizines moderately dense, dichotomously branched, black. *Apothecia* common, sessile, 1.0-2.5 mm wide; disc shallowly concave, pale brown to black; thalline exciple smooth, margin involute at first, dentate. *Ascospores* ellipsoid, 8-9 x 4.5-5.5 µm. *Pycnidia* black, immersed. *Conidia* weakly bifusiform, 6-8 x 1 µm.

Chemistry. Cortex K+ yellow; medulla K-, C-, KC-, P-; containing atranorin (major), chloroatranorin (minor), lichesterinic acid (major), protolichesterinic acid (trace), unknown fatty acid (minor).

Hypotrachyna neosingularis resembles the South American species *H. singularis* (Hale) Hale (Hale 1975); the two species have similar adnate thalli with broad, irregular to sublinear lobes with lobulate margins, lack soredia and isidia and contain fatty acids in the medulla. However, *H. neosingularis* can clearly be separated from *H. singularis* by the smaller spores (8-9 x 4.5-5.5 µm *cf.* 10-12 x 6-7 µm wide) and the shape of the lobules: rounded and almost circular in *H. neosingularis*, but narrow and strap-shaped (to 5 mm long and 1 mm wide) in *H. singularis*. The species also differ in the nature of the medullary fatty acids. *Hypotrachyna singularis* contains dehyroprotoconstipatic acid (major), praesorediosic acid (major), protoconstipatic acid (minor), constipatic acid (minor) and praesorediosic acid (minor) whereas *H. neosingularis* contains lichesterinic acid (major), protolichesterinic acid (trace) and an unknown fatty acid (minor). At present, the new species is known only from the type locality.

Melanelia gomukhensis Divakar, Upreti & Elix, sp. nov. Fig. 2

Thallus ut in *Melanelia poeltii* sed pseudocyphellis densus, sorediatibus vel pseudoisidiatibus differt.

Type: INDIA. Uttar Pradesh: Uttarkashi district, on way to Gomukh, 10 km from Gangotri, *ca.* 3475 m, on bark, *D. D. Awasthi & S. R. Singh 8343B*, 30 June 1976; holo: AWAS.

Thallus corticolous, foliose, adnate, to 9 cm wide. *Lobes* contiguous to weakly imbricate, irregular, irregularly branched, 2-3 mm wide; apices subrotund. *Upper surface* red-brown to dark brown, flat or weakly concave, smooth, shiny at the apices but dull within, emaculate; isidia absent, densely pseudocyphellate; pseudocyphellae laminal, fleck-like and whitish at first but soon darkening and expanding, rounded or irregular, becoming sorediate; soredia coarse granular, becoming ±partly corticate and developing into pseudoisidia; pseudoisidia globose. *Medulla* white. *Lower surface* shiny, minutely wrinkled, black but dark brown at the margins; rhizines sparse to moderately dense, simple, brown to dark brown. *Apothecia* and pycnidia absent.

Chemistry. Cortex K-, HNO_3-; medulla K+ pale yellow-brown, C-, KC-, P+ orange-red; containing fumarprotocetraric acid (major), protocetraric acid (trace).

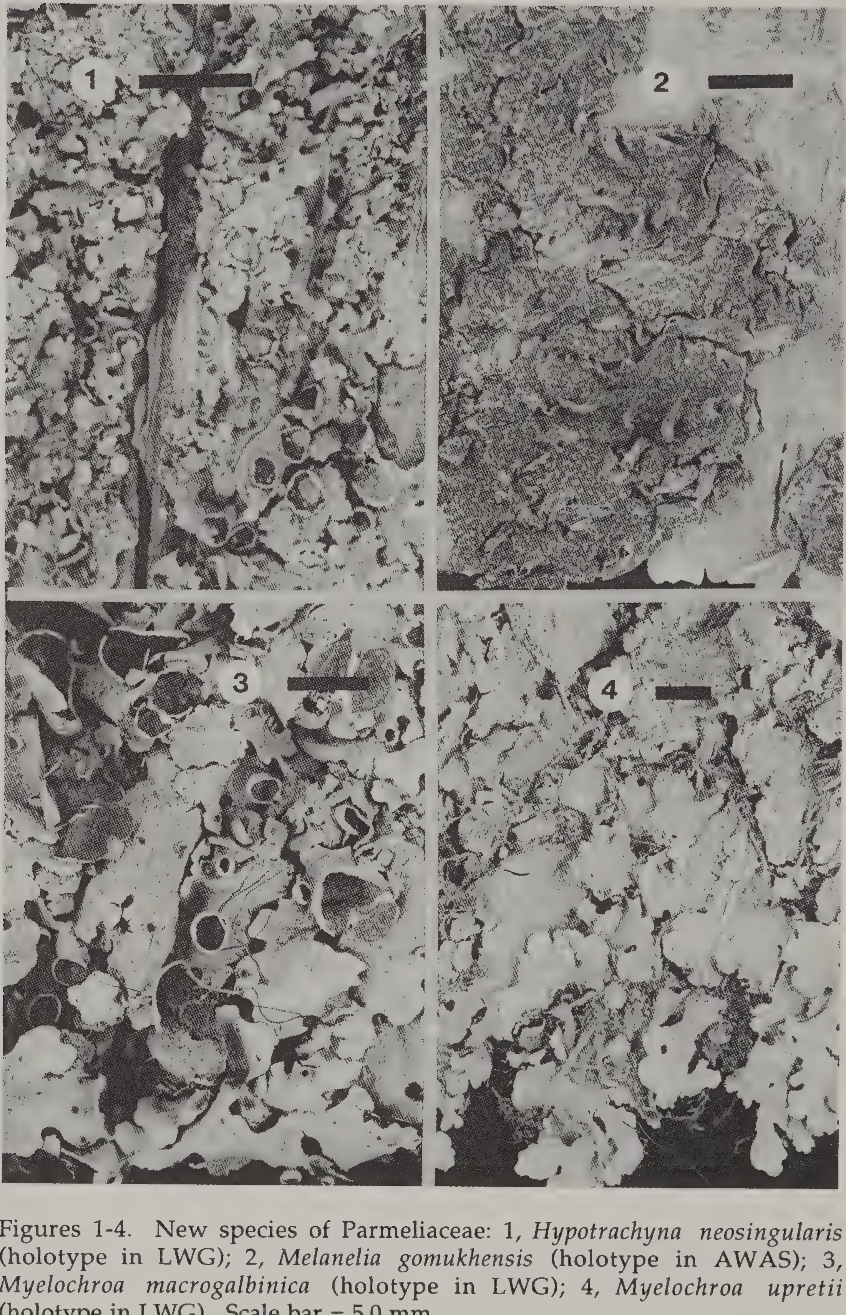
This species is characterized by the adnate thallus with relatively broad lobes which develop dense, laminal, fleck-like pseudocyphellae near the lobe apices, pseudocyphellae which expand with age to form coarse, granular soredia which in turn darken, becoming partially corticate and forming pseudoisidia, and the medullary fumarprotocetraric acid. The presence of fumarprotocetraric acid and isidia (or pseudoisidia) are reminiscent of *Melanelia poeltii* Essl. from Nepal (Esslinger 1987). However, in *Melanelia poeltii* the pseudocyphellae are sparse or absent on some lobes, the isidia develop on small, more or less spherical papillae, and the isidia are cylindrical to irregular and become branched. By contrast, the pseudoisidia of *M. gomukhensis* develop from granular soredia contained within the cavity of the pseudocyphella. At present, the new species is known only from the type locality.

Myelochroa macrogalbinica Divakar, Upreti & Elix, sp. nov. Fig. 3

Thallus ut in *Myelochroa galbina* sed laxe adnatus, lobis latioribus, densus ciliatibus, apotheciis latiore et sporis majoribus differt.

Type: INDIA. Uttar Pradesh: Almora district, Dhakuri, 2700 m, on twig, *A. Singh 89301/A*, 22 May 1972; holo: LWG.

Thallus corticolous, foliose, loosely adnate, to 8 cm wide. *Lobes* imbricate, sublinear to subirregular, irregularly branched, apically subrotund, 2-6 mm wide; margins ciliate; cilia dense, simple, regularly dispersed, 0.5-1.0 mm long. *Upper surface* pale grey becoming pale brown in the herbarium, flat to undulate, shiny at the apices, dull within, ±white-maculate, becoming rugulose with age, lacking isidia and soredia. *Medulla* lemon-yellow to pale yellow. *Lower surface* black, brown in a narrow marginal zone; rhizines dense, black, simple or squarrose branched, 1-2 mm long. *Apothecia* common, substipitate, 2-15 mm wide; disc shallowly concave, then flat and becoming undulate-distorted and irregularly cracked with age, dark brown; thalline exciple smooth at first then rugose; margin thin. *Ascospores* broadly ellipsoid, 14-25 x 9-13 µm. *Pycnidia* black, immersed. *Conidia* weakly bifusiform, 4.5-6.5 x 1 µm.



Figures 1-4. New species of Parmeliaceae: 1, *Hypotrachyna neosingularis* (holotype in LWG); 2, *Melanelia gomukhensis* (holotype in AWAS); 3, *Myelochroa macrogalbinica* (holotype in LWG); 4, *Myelochroa upretii* (holotype in LWG). Scale bar = 5.0 mm.

Chemistry. Cortex K+ yellow; medulla K+ yellow then dark red, C-, P+ orange-red; containing atranorin (minor), galbinic acid (major), salazinic acid (minor), secalonic acid R (major), secalonic acid W (major), secalonic acid C (trace), zeorin (major), 16β-acetoxyhopane-6α,22-diol (minor), ursolic acid (trace), unknown terpene (trace).

For the most part, the chemistry of this new species is identical with that of the widespread *Myelochroa galbina* (Ach.) Elix & Hale, and furthermore, both species lack vegetative propagules. However, *M. macrogalbinica* differs from *M. galbina* in having loosely adnate thalli (adnate in *M. galbina*), broader lobes (2-5 mm *cf.* 1-2 mm wide), dense marginal cilia (sparse or restricted to lobe axils in *M. galbina*), wider apothecia (2-15 mm *cf.* 2-5 mm wide) and larger spores (14-25 x 9-13 μm *cf.* 10-13 x 7-9 μm). In addition, *M. galbina* contains secalonic acid A rather than secalonic acid R or secalonic acid W as a major medullary pigment.

Three known secalonic acid derivatives (ergochromes) have been reported from lichen sources, namely secalonic acid A (ergochrome AA), secalonic acid B (ergochrome BB) and secalonic acid C (ergochrome AB) (Elix *et al.* 1988; Huneck & Yoshimura 1996). In addition, a number of related, but structurally undefined secalonic acid derivatives have been detected in various lichen species including *M. macrogalbinica.* These and related compounds appear to be widely distributed in lichens and a further 12 such compounds (secalonic acids M-Z), each characterized by their TLC, HPLC and ultraviolet spectral properties, have been identified by Elix and Wardlaw (*ined.*). At present, *M. macrogalbinica* is known from several locations in Uttar Pradesh, western Himalayas, India, whereas *M. glabina* is more widely distributed in North America and Japan (Hale 1976b).

Paratype Specimen Examined
INDIA. Uttar Pradesh: Chamoli district, on way from Chopta Tungnath peak, 3700-4300 m, over mosses, *K. Dange 76-565,* 24 Sept. 1976 (LWG).

Myelochroa upretii Divakar & Elix, sp. nov. Fig. 4

Thallus ut in *Myelochroa metarevoluta* sed lobis sublineariter vel subirregulariter, latioribus et soraliis subpustulatis differt.

Type: INDIA. Uttar Pradesh: Pithoragarh district, en route from Shan-dev to Didihat, 1900 m, on *Rhododendron* in *Quercus* forest, *D. K. Upreti 201965,* 21 Nov. 1989; holo: LWG; iso: CANB.

Thallus corticolous, foliose, loosely adnate to adnate, to 11 cm wide. *Lobes* imbricate, sublinear to subirregular, irregularly branched, apically subrotund, 2-10 mm wide; margin ciliate; cilia simple, irregularly dispersed but mainly in the lobes axils, to 0.5 mm long. *Upper surface* pale mineral-grey becoming yellow-brown in the herbarium, flat, shiny, emaculate, becoming rugulose with age, lacking isidia, sorediate; soralia subpustulate, originating marginally or submarginally, ±spreading laminally; soredia granular; marginal lobes weakly revolute. *Medulla* mostly white, pale yellow in some places. *Lower surface* black, brown in a narrow marginal zone; rhizines dense, black, simple or rarely dichotomously branched, 0.5-1.5 mm long. *Apothecia* and *pycnidia* not seen.

Chemistry. Cortex K+ yellow; medulla K+ yellow then dark red, C-, P+ orange-red; containing atranorin (minor), galbinic acid (major), salazinic acid (minor), norstictic acid (trace), pigmentosin B (minor), secalonic acid R (minor), secalonic acid W (minor), secalonic acid C (trace), zeorin (major), 16β-acetoxyhopane-6α,22-diol (minor), ursolic acid (trace), unknown terpene (trace).

This species is most likely to be confused with *Myelochroa metarevoluta* (Asah.) Elix & Hale, but these species differ both chemically and morphologically. Whereas *Myelochroa metarevoluta* has dichotomously branched, sublinear-elongate lobes which are ascending at the apices, and has capitate soralia, the lobes of *M. upretii* are broader (2-10 mm *cf.* 1-6 mm wide), sublinear to subirregular, irregularly branched, weakly revolute and subrotund at the apices, and has subpustulate soralia. In addition, *M. metarevoluta* contains secalonic acid A rather than secalonic acid R, secalonic acid W or pigmentosin B as a major medullary pigment. Pigmentosin B (the major K+ wine-red pigment present in *Myelochroa amagiensis* (Asah.) Elix & Hale and *M. denegans* (Nyl.) Elix & Hale) is one of a constellation of such pigments previously referred to as the "schenckiana pigments" (Hale 1990). *Myelochroa upretii* also appears to be related to *Myelochroa salazinica* Wang, Chen & Elix (2001), a similar sorediate species from China. However, *M. salazinica* differs in having capitate soralia and in containing salazinic acid and leucotylic acid as major constituents, whereas *M. upretii* has subpustulate soralia and contains major quantities of galbinic acid and 16β-acetoxyhopane-6α,22-diol. Kurokawa & Arakawa (1997) have suggested that triterpene profiles are very variable in *Myelochroa* and should not be used as a species character, but we disagree. In our experience, the triterpene profiles in *Myelochroa* are typically species-specific (as they are in many other genera including *Heterodermia, Physcia, Pseudocyphellaria* and *Pyxine*) as are the pigment profiles (including eumitrins, secalonic acids and pigmentosins). At present, *M. upretii* is only known from the type locality in northern India whereas *M. metarevoluta* is more widely distributed in the eastern United States, Japan, China (Hale 1976b, Wei 1991, Zhao 1964) and India (Patwardhan & Nagarkar 1982). *Myelochroa upretii* appears to be the sorediate counterpart of *M. macrogalbinica*. This species is named in honour of the collector, renowned for his many contributions to Asian lichenology.

New Records of Parmeliaceae for India

Parmotrema crinitoides C.J. Wei, *Enum. Lichens of China*: 177 (1991).

This species is characterized by the fragile cortex, the absence of cilia, dense laminal and marginal isidia which are short-cylindrical, becoming coralloid, granular, and the stictic acid chemosyndrome in the medulla. *Parmotrema crinitoides*, previously known from China (Wei 1991) and Australia (Elix & Streimann 1999), appears to be an eciliate morphotype of *P. crinitum* (Ach.) M. Choisy.

Specimen Examined
INDIA. Kerala: Idukki district, Mattupatty near Munnar, Swiss project area, 1600-1700 m, on bark of *Erythrina* tree, *D. D. Awasthi, R. Tewari & R. Mathur 85223,* 25 Mar. 1985 (AWAS).

Relicinopsis dahlii (Hale) Elix & Verdon, *Mycotaxon* **27**: 281 (1986)

Relicinopsis dahlii is distinguished by the contiguous, sublinear-elongate lobes, the presence of cylindrical isidia, the pale brown, densely rhizinate lower surface and the presence of cortical usnic acid and medullary evernic acid (absent in the type material) and lecanoric acid. Previously this species was only known from Sri Lanka (Hale 1976a).

Specimen Examined
INDIA. Kerala: Quilon, on bark, *E. K. Santha A80,* 1958 (AWAS).

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A NEW SPECIES OF XANTHOPARMELIA (LICHENIZED ASCOMYCOTINA, PARMELIACEAE) FROM SPAIN

ANA CRESPO

Departamento de Biología Vegetal II, Facultad de Farmacia, Universidad Complutense de Madrid, 28040 Madrid, Spain
email: acrespo@eucmax.sim.ucm.es

MARÍA del CARMEN MOLINA

Departamento de Biología Vegetal II, Facultad de Farmacia, Universidad Complutense de Madrid, 28040 Madrid, Spain
and
Departamento de Ciencias Experimentales e Ingenieria, Escuela Superior de Ciencias Experimentales y Tecnología, Universidad Rey Juan Carlos, 28933 Madrid, Spain
email: cmolina@escet.urjc.es

JOHN A. ELIX

Department of Chemistry, The Faculties, Australian National University, Canberra, ACT 0200, Australia
email: John.Elix@anu.edu.au

ABSTRACT : *Xanthoparmelia vicentii* (Parmeliaceae) from Spain is described as new to science. This species is characterized by revolute laciniate-lobulae, the lack of isidia, a black lower surface and the stictic acid chemosyndrome in the medulla.

KEY WORDS: *Xanthoparmelia vicentii*, stictic acid, Europe

Introduction

Although *Xanthoparmelia* represents the largest genus of foliose lichens with in excess of 500 species worldwide, it is poorly represented in Europe with just 15 species recorded (Hale 1990). Furthermore, the genus *Xanthoparmelia* shows extraordinary chemical variation (with more than 40 chemosyndromes represented), but only four of these chemosyndromes are represented among the European species (viz. fumarprotocetraric acid, norstictic acid, salazinic acid and stictic acid). In the present work we are describing a new species from western Spain which contains the stictic acid chemosyndrome. Throughout the present work chemical constituents were identified by thin layer chromatography (Culberson 1972; Culberson & Johnson 1982; Elix & Ernst-Russell 1993), high performance liquid chromatography (Elix *et al.* 1997; Feige *et al.* 1993) and comparison with authentic samples.

Xanthoparmelia vicentii A. Crespo, M. C. Molina & Elix, sp. nov. Figs. 1,2

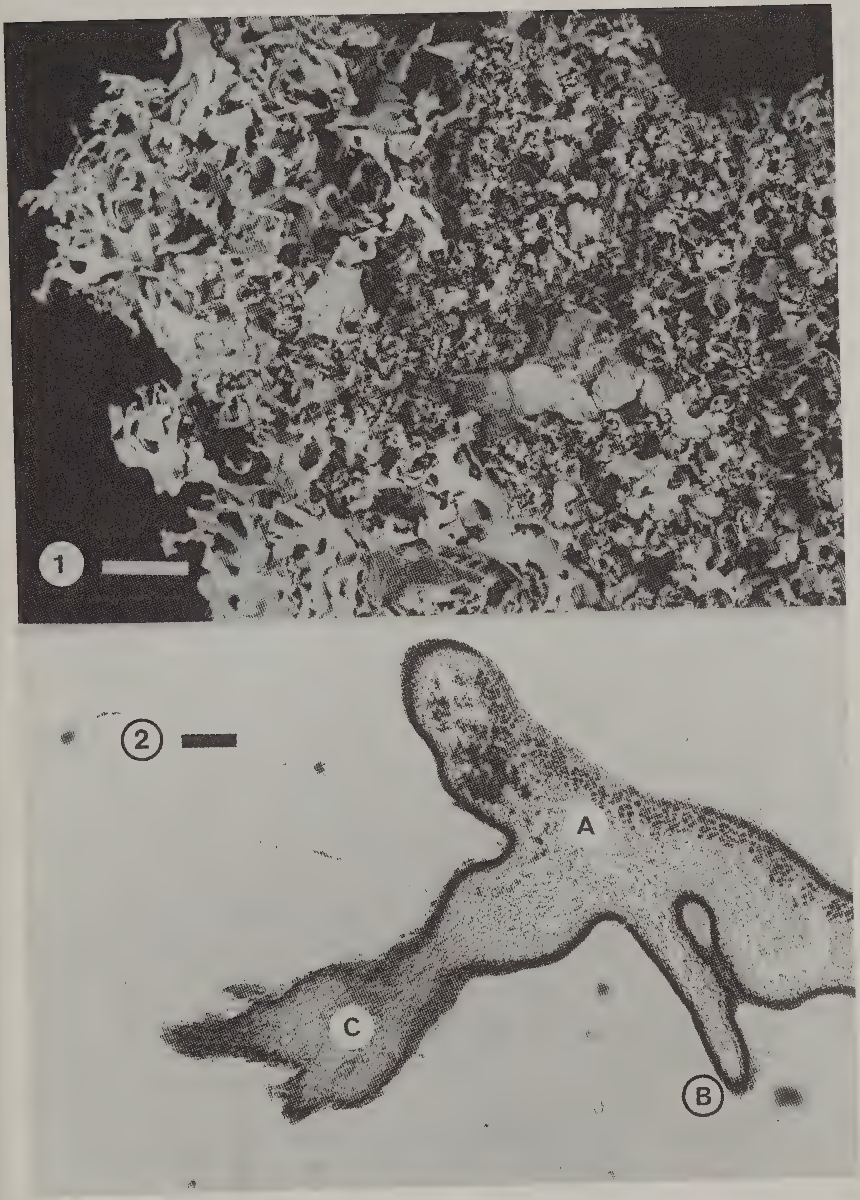
Thallus ut in *Xanthoparmelia angustiphylla* sed laciniae revolutis vel subcylindricis et rhizinis sparsim et parce ramosis differt.

Type: SPAIN. Salamanca: Béjar, El Castañar (hacia Candelario), 1200 m, on granite rocks, *Crespo & Molina,* 14 Nov. 2000; holo: MAF-lich 7248; iso: CANB.

Thallus saxicolous, foliose, loosely adnate to adnate, to 7 cm wide. *Lobes* loosely imbricate, subirregular, irregularly branched, 1-3 mm wide; densely laciniate-lobulate in thallus centre, laciniae sublinear, ascending, extensively subdichotomously to subirregularly branched, revolute to subterete, black-tipped at apices, 0.2-0.8 mm wide. *Upper surface* yellow-green, undulate to weakly convex, emaculate, ±with blackened margins, smooth and shiny at apices, older lobes dull, rugulose, isidia and soredia absent. *Medulla* white. *Lower surface* black, brown or mottled at the margins, rugulose, canaliculate; rhizines sparse, simple or rarely branched, ±tufted at apices, black. *Apothecia* and pycnidia not seen (although primordial pynidia have been observed below the lobe surface).

Chemistry. Cortex K-; medulla K+ yellow then red, C-, KC+ yellow then red, P+ orange-red; containing usnic acid (major), stictic acid (major), norstictic acid (minor), constictic acid (minor), cryptostictic acid (trace), lusitanic acid (trace).

Both *X. vicentii* and *X. angustiphylla* (Gyeln.) Hale are nonisidiate relatives of *X. conspersa* (Ach.) Hale, with the stictic acid chemosyndrome present in the medulla. *Xanthoparmelia vicentii* differs from *X. angustiphylla* in having dense, ascending, revolute to subterete laciniate-lobules in the thallus centre whereas the laciniae of *X. angustiphylla* are flat and densely imbricate. In addition, *X. angustiphylla* has moderately dense, simple rhizines whereas those of *X. vicentii* are sparse, and occasionaly branched and ±tufted at the apices. These two species also show quite distinctive geographic distributions, *X. angustiphylla* occurring in North America and northern Europe (Belgium, Czech Republic, Germany, Poland, Hungary and Sweden), while *X. vicentii* is restricted to western Spain. Among the non-European species, *X. vicentii* resembles *X. austrocapensis* Hale from South Africa. However, *X. austrocapensis* has more elongate, dorsiventral, divaricate, dichotomously branched laciniae which are weakly revolute at the apices in contrast to the short, ascending, crowded, subdichotomously to subirregularly branched laciniae of *X. vicentii* which are



Figures 1,2. Aspects of *Xanthoparmelia vicentii*. 1, *Xanthoparmelia vicentii* (isotype in CANB), scale bar = 5.0 mm; 2, Transverse section of lobe apex (A) of *X. vicentii*, illustrating lobule (B) and rhizine (C) formation, scale bar = 30 µm.

more markedly revolute and subterete at the apices. This species is named in honour of the Professor Carlos Vicente in recognition of his many contributions to lichenology.

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NEW TAXA AND NEW REPORTS IN THE LICHEN FAMILY GRAPHIDACEAE (ASCOMYCOTINA) FROM AUSTRALIA

ALAN W. ARCHER

National Herbarium of New South Wales
Mrs. Macquaries Road, Sydney, NSW 2000, Australia

Abstract: *Graphis paradoxica, G. stipitata* and *G. stenospora* var. *deficiens* are described as new to science and *Graphina dimidata, G. incerta* and *Graphis longula* are reported for the first time from Australia. 2-Methoxypsoromic acid is reported from the Graphidaceae for the first time and is present in *Graphis paradoxica, G. elixii* and *Graphina psoromica.*

KEY WORDS: *Graphis paradoxica, G. stipitata, G. stenospora* var. *deficiens*
2-methoxypsoromic acid

Introduction Australian species in the lichen genera *Graphina* Müll. Arg. and *Graphis* Adans. have recently been discussed: *Graphina* (Archer 1999, 2001) and *Graphis* (Archer 1999, 2001a). An examination of recent collections in CANB has shown the presence of three new taxa described here and in addition three species are reported for the first time from Australia.

Material and methods This account is based on the examination of type and other specimens from G, NSW, S and TUR and in particular the recent collections made by J.A. Elix and H. Streimann (CANB). The techniques used were described previously (Archer 1999, 2000).

NEW TAXA

Graphis paradoxica A.W. Archer, *sp. nov.* Fig. 1a, Fig. 2

Similis *Graphis elixii* A.W. Archer sed excipulo deficiente differt.

Type: AUSTRALIA. New South Wales: Buckenbowra River Estuary, 7.5 km W of Batemans Bay, 35°42'E, 150°06'S, alt. 1 m, in closed rain forest on tree along tidal creek, *J.A. Elix 23345, 29.xi.1989*; holotype: CANB.

Thallus pale fawn, thin, corticolous, surface smooth and shiny; *apothecia* lirelliform, conspicuous, sessile, concolorous with the thallus, scattered, simple, straight or curved, 1-5 mm long, 0.6-1 mm wide, lips closed, reddish brown, with a conspicuous thalline margin; *proper exciple* uncarbonised, reddish brown, complete; *hymenium* 100-120 μm tall, I-ve; *ascospores* 8 per ascus, irregularly 1-seriate, hyaline, ellipsoid, 16-18(-26) μm long, 6-10 μm wide, 4-locular, I+ pale blue.

Chemistry: 2-methoxypsoromic acid (major) ± norstictic acid (trace-minor)

Specimens examined:
NEW SOUTH WALES: Buckenbowra River, 77.5 km WNW of Batemans Bay, 35°32'S, 150°07'E, alt. 2 m, on *Casuarina*, *J.A. Elix 26561*, 15.iii.1992 (CANB); Dorrigo National Park, on tree by side of track to Tristania Falls, *A.W. Archer G 528*, 1.xi.2000 (NSW).

Graphis paradoxica is characterised by the conspicuous, pale lirellae, the small 4-locular ascospores and the presence of 2-methoxypsoromic acid. Norstictic acid may also be present in variable concentrations. The new species resembles the chemically similar species *Graphis elixii* A.W. Archer (Archer 1998) but is distinguished from that species by the uncarbonised proper exciple which is laterally carbonised in *G. elixii*. 2-Methoxypsoromic acid was first isolated and identified from specimens of *Pertusaria* and *Sulcaria* (Elix *et al.* 1999); this is the first report of the compound in the genus *Graphis*.

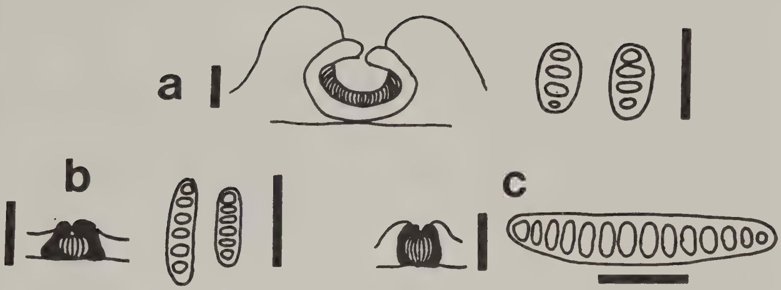
Both *Graphis elixii* A.W. Archer (Archer 1998) and *Graphina psoromica* A.W. Archer (Archer 2001) were reported to contain psoromic acid. However, psoromic acid is indistinguishable from 2-methoxypsoromic acid by thin-layer chromatography and both compounds give the same colour reactions with sulphuric acid and *p*-phenylenediame (P). The Rf values (for psoromic and 2-methoxypsoromic acids respectively) for solvents A, B^1 and C (Culberson 1972; Culberson & Johnson 1982) are: 36, 35; 46, 44; 41, 39. The two compounds can be separated and identified by liquid chromatography (Feige *et al.* 1993; Elix *et al.* 1999) and a re-examination of the type specimens of *Graphis elixii* and *Graphina psoromica* showed that both contained 2-methoxypsoromic acid.

Graphis paradoxica is so far known only from the three specimens cited above but similar specimens are known from New South Wales; two (Archer G 202 and G 515) lack lichen compounds and a third contains subsporomic acid (B. Staiger, *in litt.* 2000), recently isolated from *Ocellularia praestans* (Müll. Arg.) Hale (Elix *et al.* 2000). The taxonomic position of these specimens is, at present, unclear.

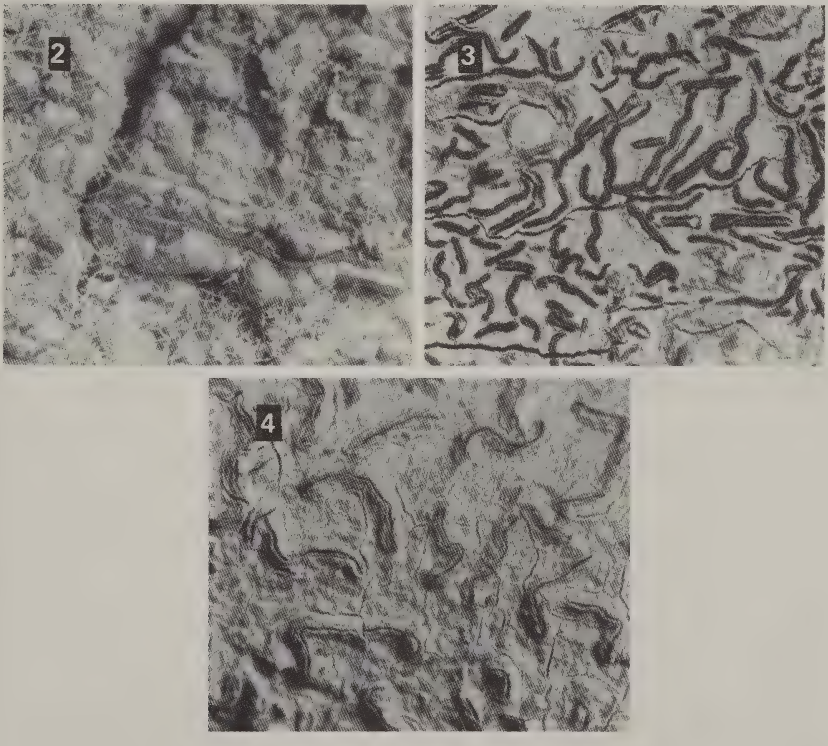
The epithet *paradoxica*, contrary to expectation, refers to the unexpected presence of 2-methoxypsoromic acid.

Graphis stipitata A.W. Archer, *sp. nov.* Fig. 1b, Fig. 3.

Similis *Graphis librata* C. Knight sed ascosporis minoribus et lichexanthone continens differt.



Figs.1a-c. *Graphis* species:
a. *G. paradoxica;* b: *G. stipitata;* c. *G. stenospora* var. *deficiens.*
Lirellae: bar = 200μm; ascospores: bar = 20 μm



Figs. 2-4. *Graphis* species x 12.5
2. *G. paradoxica* (holotype, CANB); 3. *G. stipitata* (holotype, CANB);
4. *G. stenospora* var. *deficiens* (holotype, CANB).

Type: AUSTRALIA. QUEENSLAND: Yungaburra Road, 2 km SE of Atherton, 17°16'S, 145°29'E, alt. 850 m, on *Casuarina, H. Streimann 16826*, 27.ii.1983; holotype: CANB; isotypes: H, US.

Thallus off-white, thin, corticolous, surface smooth and dull; *apothecia* lirelliform, numerous, crowded, narrow, subimmersed, straight, curved or sinuous, sometimes branched, lips closed, 0.5-2 mm long, 0.1-0.15 mm wide; *proper exciple* laterally carbonised; *hymenium* 80-90 µm tall, I-ve; *ascospores* 8 per ascus, irregularly 2-seriate, hyaline, narrow ellipsoid, 15-20 µm long, 5-6 µm wide, 5-6 locular, I+ blue.

Chemistry: lichexanthone (major), norstictic acid (minor) and connorstictic acid (trace); thallus UV+ yellow.

Graphis stipitata is characterised by the laterally carbonised proper exciple, the small, 5-6 locular ascospores and the presence of norstictic acid and lichexanthone. The latter compound produces a bright yellow fluorescence in the thallus when examined under long wavelength UV light (*ca.* 365 nm). Lichexanthone is an uncommon compound in the Graphidaceae and is reported from *Graphis candidata* Nyl., *G. chionophora* Redinger, *Graphina tetraphora* (Nyl.) Zahlbr. (Staiger & Kalb 1999), *Graphina confluens* (Fée) Müll. Arg. (Wirth & Hale 1978), *Graphina anguina* (Mont.) Müll. Arg. and *Phaeographis punctiformis* (Eschw.) Müll. Arg. (Harris 1995). *Graphis stipitata* is the first *Graphis* species found to contain lichexanthone together with norstictic acid, although this combination has been reported from *Graphina tetraphora* (Staiger & Kalb 1999). The new species is so far known only from the type specimen.
The epithet *stipitata*, crowded, refers to the numerous, crowded lirellae in this species.

Graphis stenospora Müll. Arg. var. **deficiens** A.W. Archer, *var. nov.*
Fig. 1c, Fig.4.

Similis *Graphis stenospora* Müll. Arg. sed acido stictico deficiente differt.

Type: AUSTRALIA. NEW SOUTH WALES: Richmond Range State Forest, Cambridge Plateau Drive, 29 km SW of Kyogle, on *Eucalyptus microcorys, H. Streimann 61366*, 24.iv.1998 (CANB).

Thallus ashy-grey, thin, somewhat cracked, corticolous, surface smooth and slightly shiny; *apothecia* lirelliform, numerous, conspicuous, scattered, straight, curved or sinuous, sometimes branched, sessile, 1-3 mm long, 0.15-0.2 mm wide, lips closed, with a conspicuous thalline margin; *proper exciple* laterally cabonised, sometimes almost completely carbonised; *hymenium* 100-120 µm tall, I-ve; *ascospores* 8 per ascus, irregularly 2-seriate, hyaline, narrow ellipsoid, (50-)54-70(-74) µm long, 9-12 µm wide, 12-16 locular, I+ blue.

Chemistry: no compounds found.

Specimens examined:
New South Wales: Cambridge Plateau Drive, near Pawpaw Skids Road, 25 km WSW of Kyogle, *H. Streimann 61301*, 25.iv.1998 (CANB); Marsh State Forest, Mount Gibraltar, 24 km NNW of Taree, *H. Streimann 60534*, 17.iv.1998 (B, CANB).

Graphis stenospora var. *deficiens* is characterised by the conspicuous lirellae, the large ascospores and the absence of lichen compounds. This latter feature distinguishes the new variety from var. *stenospora* Müll. Arg. which contains stictic acid. *Graphis stenospora* was described by Müller (1882) and was based on a specimen collected in Java [Indonesia]. The ascospores in the type specimen were reported to be 55-65 µm long and 12-15 locular, and the lirellae are laterally carbonised, *cf.* Redinger Taf. II, Fig. 18 (Redinger 1936). The new variety resembles *Graphis catherinae* A.W. Archer (2001a) but that species has immersed lirellae and slightly smaller ascospores.
So far var. *stenospora* has not so far been found in Australia; var. *deficiens* occurs in New South Wales.

NEW RECORDS FOR AUSTRALIA

Graphina dimidata (Vain.) Zahlbr.
in *Cat. Lich. Univers.* **2**: 404 (1923).

= *Graphis dimidata* Vain.
in *Acta Soc. Fauna et Flora Fenn.* **7**(2): 108 (1890).

Type: BRAZIL. Minas Gerais, Lafayette [Conselherio Lafaiete], *E.A. Vainio 332*, Mar. 1885; lectotype: TUR-V 27241 (*fide* Wirth & Hale 1978).

Thallus pale fawn, thin, corticolous, suface smooth and dull; *apothecia* lirelliform, scattered, sessile, simple, straight or curved, 0.5-1.5 mm long, 0.15-0.2 mm wide, lips initially closed, becoming slightly open, with a thin thalline margin at the base; *proper exciple* laterally carbonised; *hymenium* 80-100 µm tall. I-ve; *disc* faintly white pruinose; *ascospores* 8 per ascus, irregularly 1-seriate, narrow ellipsoid, hyaline, 20-28 µm long, 8-10 µm wide, 6-8 x 2-3 locular, I+ blue.

Chemistry: no compounds found (*fide* Wirth & Hale 1978).

Illustration: Redinger Taf III, Fig. 29 (1933); Wirth & Hale Fig. 9d, Plate 8b (1978).

Specimens examined:
Northern Territory: Umbrawarra Gorge, 22 km SW of Pine Creek, 13°58'S, 131°42'E, alt. 200 m, on *Melaleuca*, *J.A. Elix 28077*, 17.vii.1991 (CANB); *ibid.*, *H. Streimann 48564* (CANB).

Graphina dimidata is characterised by the slightly open, short lirellae, the small ascospores and the absence of lichen compounds. It somewhat resembles *Graphis streimannii* A.W. Archer, which also occurs in the Northern Territory, but is distinguished from that species by the smaller lirellae, the smaller, muriform ascospores and the absence of lichen compounds; *G. streimannii* contains norstictic acid. Vainio (*loc. cit.*) reported the ascospores to be muriform, 13-26 µm long and 8-10 µm wide.
The species occurs in Brazil, Dominica and, in Australia, in the Northern Territory.

Graphina incerta Redinger
in *Ark. Bot. 26A*(1): 59 (1933).

Type: PARGUAY. Colonia Risso, *O.G. Malme 3644*, 28.x.1983; lectotype (here selected): S.

Thallus pale fawn to pale greyish-white, thin, corticolous, surface tuberculate; *apothecia* lirelliform, off-white, inconspicuous, numerous, immersed, simple, straight or curved, 0.8-2 mm long, 0.2-0.35 mm wide, lips closed; *proper exciple* inconspicuous, pale yellow-brown, complete; *hymenium* 100-120 µm tall, I-ve; *ascospores* 1 per ascus, elongate-ellipsoid, hyaline, densely muriform, 80-100 µm long, 20-28 µm wide, I+ blue-violet.

Chemistry: no compounds found.

Illustration: Redinger Taf. V, Fig. 49 (1933).

Specimens examined:
QUEENSLAND: Carnarvon Highway, 4 km S of Bullaroo River Bridge, 68 km N of Injune, on dead tree in monsoon forest, *J.A. Elix 34042*, 19.viii.1993 (CANB); Capricorn Highway, 19 km ESE of Duranga, on saplings, *J.A. Elix 34433*, 22.viii.1995 (CANB).

Graphina incerta is characterised by the inconspicuous, immersed lirellae, the pale yellow-brown proper exciple and the absence of lichen compounds. *Graphina incerta* occurs in Paraguay and Hawaii (Magnusson 1955: 270) and, in Australia, in Queensland.
Redinger cited two syntypes in the protologue of *G. incerta*. One of these, *Malme 1890f*, contains protocetraric acid and was identified as *Graphis abaphoides* Nyl. [= *Acanthothecis abaphoides* (Nyl.) Staiger & Kalb (Staiger & Kalb 1999)]; the other, Malme 3644 lacked lichen compounds and is here selected as lectotype.

Graphis longula Kremp.
in *Flora* **59**: 414 (1876).

= *Phaeographis longula* (Kremp.) Zahlbr.
in *Cat. Lich. Univ.* **2**: 379 (1923).

Type: BRAZIL, s.loc., *Glaziou 5497*; lectotype: M (*fide* Wirth & Hale 1978).

Thallus pale olive-green, thin, corticolous, surface subtuberculate and slightly shiny; *apothecia* lirelline, numerous, thin, black, immersed to subimmersed, straight, curved or sinuous, sometimes branched, lips closed, 1-3(-4) mm long, 0.1-0.2 mm wide, with inconspicuous thin, thalline margin; *proper exciple* completely carbonised, weakly striate above; *hymenium* 100-120 µm tall; *ascospores* 8 per ascus, irregularly 2-seriate, hyaline, 62-80 µm long, 8-11 µm wide, 13-16 locular.

Chemistry no lichen compounds found.

Illustration: Wirth & Hale, Fig. 5e, Plate 3f (1978).

Specimens examined
QUEENSLAND: Hugh Nelson Range, 15 km S of Atherton, *J.A. Elix 16410*, 25.vi.1984 (CANB); D'Aguilar Range, W of Mt Glorious township, *J. Hafellner 16933*, 1.viii.1986 (GZU).
NEW SOUTH WALES: 'Laurina', 11 km WSW of Dorrigo, *A.W. Archer G 548*, 29.x.2000 (NSW).
VANUATU. (New Hebides); *F. Wilson s.n.*, 1895 (NSW).

Graphis longula is characterised by the weakly striate, completely carbonised proper exciple, the large ascospores and the absence of lichen compounds. The striations in the proper exciple may sometimes be inconspicuous and the lirellae then somewhat resemble those of *Graphis crassilabra* Müll. Arg. The two species are easily separated however as *G. crassilabra* contains stictic acid and the ascospores are somewhat smaller, being 55-65 µm long. Krempelhuber (*loc. cit.*) reported the ascospores in *G. longula* to be 70-75 x 9-13 µm, 10-12 locular and hyaline. The ascospores in the specimens cited above are also hyaline and the transfer of this species to *Phaeographis* by Zahlbruckner is unnecessary (Wirth & Hale 1963).
This species occurs in Brazil, Mexico, Costa Rica, Dominica and Vanuatu, and in Australia, in Queensland and New South Wales.
The only reported substrate in Australia is *Pipturus*.

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MYCOTAXON

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XANTHORIA TENUILOBA, A NEW LICHEN SPECIES FROM BAJA CALIFORNIA, MEXICO

LOUISE LINDBLOM

Department of Botany, University of Bergen, Allégaten 41, NO-5007 Bergen, Norway,
Louise.Lindblom@nhm.uio.no

Abstract: The new species *Xanthoria tenuiloba* (Teloschistaceae, lichenized Ascomycotina) is described from Baja California, Mexico. It is characterized by a mostly greyish, subfruticose-fruticose thallus with very narrow and slender, nodulose lobes, and abundant blastidia. Apothecia and pycnidia are always orange pigmented, and conidia are ellipsoid. It grows on dry twigs and occasionally on rock in near-coastal scrub vegetation.

Keywords: Flora of North America, lichenized ascomycetes, Teloschistaceae, HPTLC

INTRODUCTION

During studies for the revision of the genus *Xanthoria* in North America north of Mexico (Lindblom 1997), I studied several additional specimens from Mexico. The material consisted mainly of specimens collected on recent field trips arranged by the Sonoran Desert Lichen Flora Project. A peculiar taxon was noted, but it was not included in the thesis, since no material from north of the Mexican border was found. Furthermore, it was necessary to study whether it could be assigned to the genus *Xanthoria*. As a part of my work for the Sonoran Lichen Flora project, it is now suitable to properly publish the new species.

MATERIAL AND METHODS

Material from ASU, BG, C, CAS, COLO, G, GZU, H, LD, MIN, NY, O, TUR, UPS, US, and WIS was studied, in all c. 25 specimens. In addition, several specimens occurring mixed in collections of *Xanthoria tenax* were investigated (not cited in the specimen list). Only apothecia of individuals that did not belong to the intermingled *X. tenax* were chosen for making sections. The secondary chemistry of 10 specimens was screened using HPTLC (Arup et al. 1993, Lindblom 1997). Measurements are given as (minimum value recorded-)lowest specimen arithmetic mean observed-highest specimen arithmetic mean observed(-maximum value recorded), or just minimum value recorded-maximum value recorded.

DESCRIPTION

Xanthoria tenuiloba L.Lindblom, **sp. nov.** Fig. 1

Thallus suffruticosus ad fruticosus, plerumque canus interdum flavus ad aurantiacus, sorediatus. Lobi horizontales ad erecti, latitudine variabiles, plerumque tenuissimae, nodulosae. Apothecia frequentia, aurantiaca. Sporae polaridiblastae, ellipsoideae, (11.0-)12.1-14.2(-16.0) µm longae, (4.5-)5.1-5.8(-7.0) µm crassae, septum (2.0-)2.6-3.6(-5.0) µm. Pycnidia frequentia, aurantiaca, conidia ellipsoidea, (2.5-) 2.75-3.05(-3.5) µm longa, c. 1-1.5 µm crassa.

Type: MEXICO. BAJA CALIFORNIA NORTE. Bahia San Quintin, 127 miles S of Ensenada, on Pacific coast; low playa with scattered low mounds, ca. 20 ft. alt.; on low shrubs of *Lycium californicum*. 23 April 1966, W. A. Weber & R. Santesson, Lich. Exs. COLO No. 190 (COLO - holotype; ASU, BG, C, GZU, H, LD, MIN, NY, O, TUR, UPS, US, WIS - isotypes).

Etymology: *tenuiloba*; *tenuis*, slender, and *-lobus*, with lobes.

Thallus subfruticose-fruticose, small, up to 10-15 mm, forming more or less coalescing cushions, attached by lower parts of lobes and occasional short hapters. Lobes horizontal to semierect to erect, narrow, slender, with very variable lobe width within thallus and lobe, (0.07-)0.12-0.27(-0.6) mm, dorsiventral, outermost parts formed as very narrow branches which appears terete, nodulose. Upper surface greyish to dull yellow to orange, smooth. Lower surface white. Cortex layers paraplechtenchymatous, composed of 3-5 layers of isodiametric cells, colourless apart from external anthraquinone crystals. Photobiont of *Trebouxia* type; green, unicellular, (11-)13.2-18.4(-22) µm. Medulla reticulate. Hapters very rarely present, white, short, attached. Soredia blastidious, produced marginally and from tips and margins of extremely narrow branches.

Apothecia mostly present, but never very abundant or crowded, zeorine, laminal, appearing as pruinose swellings in primordial stage, (0.6-)0.7-1.4(-1.9) mm. Disc concave to plane, orange (also when thallus is grey). Thalline margin 0.06-0.1 mm, smooth, sometimes with blastidia, greyish to dull yellow to orange. Hymenium 35-55 µm. Subhymenium 10-60 µm. Exciple 10-20 µm. Algal layer below exciple 40-60 µm. Paraphyses simple or branched 1-3 times, 1-3 upper cells wider than the rest, tips c. 4-6 µm wide, rarely containing oil droplets. Spores ellipsoid, (11.0-)12.1-14.2(-16.0) µm long, (4.5-)5.1-5.8(-7.0) µm wide, septum wide, (2.0-)2.6-3.6(-5.0) µm.

Pycnidia laminal, numerous, immersed-somewhat protruding, orange (also when thallus grey), c. 0.1-0.2 mm diameter. Conidia ellipsoid, (2.5-)2.75-3.05(-3.5) µm long, c. 1-1.5 µm wide.

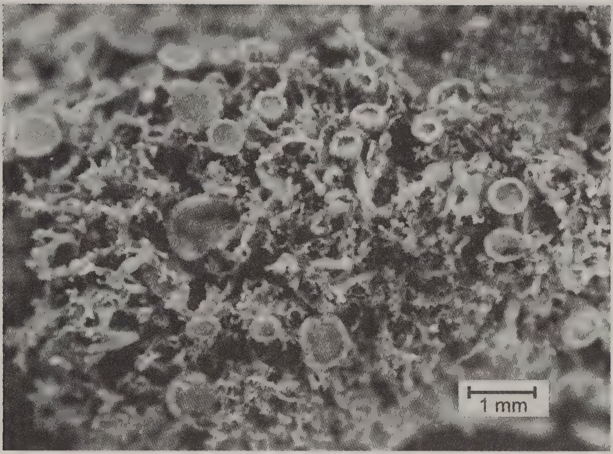

Figure 1. Morphology of *Xanthoria tenuiloba* (Westberg 244, LD). Scale bar = 1 mm.

Chemistry. Parietin and teloschistin as major substances; emodin, fallacinal and parietinic acid as minor substances. The pattern corresponds to chemical group 1 in Arup (1995a) and chemosyndrome A in Søchting (1997). Thallus and apothecia K+ red (thallus K- when grey) C-, PD-, and I-.

Ecology. Corticolous on dry, thin twigs of shrubs in near-coastal habitats. If phorophyte is stated on the herbarium labels, it is always *Lycium*, either *Lycium* sp. or specified as *L. californicum*. One collection (Wetmore 63568, MIN) was made on volcanic rock in the scrub community habitat, at a locality where *X. tenuiloba* was also collected on *Lycium*. Material of the species has never been collected more than 250 m above sea level.

Distribution. *Xanthoria tenuiloba* was recorded from a few, rather closely situated, localities in the western Baja California area (Fig. 2). It is remarkable that it has not been collected elsewhere in the coastal areas of southern California or Baja California. Lichenologists have visited several similar localities during the Sonoran Desert Lichen Flora Project (http://mgd.nacse.org/Arizona/sonoran.desert/Sonoran.desert.html). One would assume that a peculiar Teloschistaceae taxon like *X. tenuiloba* would be collected every time it was noticed. It apparently has a very restricted distribution, although it seems to be abundant on the localities where it was found.

It could be expected that *X. tenuiloba* could also occur at other similar coastal situations, for example in South America. I have seen some collections from such areas, the most recent from a field expedition in January 2001 (Ulf Arup and Patrik Frödén, Lund University). However, I have yet to see *X. tenuiloba* in collections from any other part of the world.

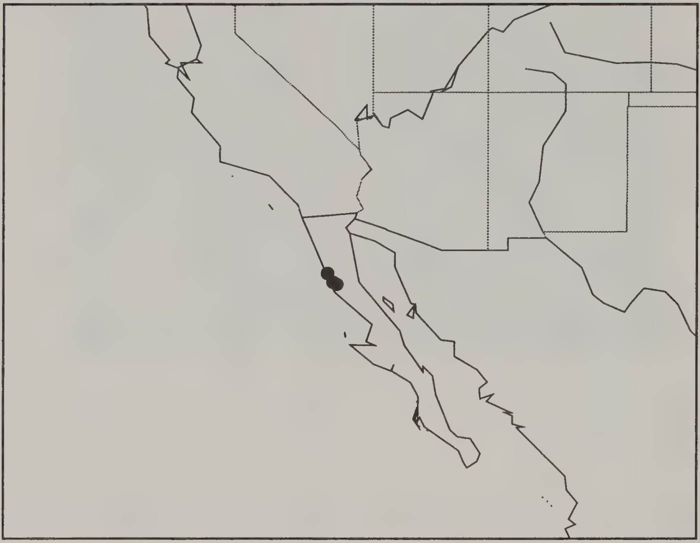

Figure 2. Known distribution of *Xanthoria tenuiloba*.

Notes. This species is characterized by its small and tender, subfruticose-fruticose thallus with blastidiate, narrow, slender, nodulose, more or less upright lobes, and by growing on dry, more or less thin twigs.

The main habitus and gross morphology separates *X. tenuiloba* from *X. candelaria*. The lobes of *X. tenuiloba* are narrower and not as densely crowded. The colour of the thallus is mostly greyish or dull yellow, and very rarely as brightly pigmented as *X. candelaria*. In addition, *X. tenuiloba* seems to be confined to dry twigs of shrubs in near-coastal habitats.

Xanthoria polycarpa frequently occurs on twigs and has rather slender lobes, but differs from *X. tenuiloba* by being non-sorediate and having mostly crowded apothecia, which may cover the entire thallus. Young thalli growing on very thin twigs can, however, have only a few apothecia, or lack apothecia. The apothecia of *X. polycarpa* often develop a very thick stalk, sometimes almost reaching the width of the whole apothecium. This is not the case in *X. tenuiloba*.

The distribution areas of *X. tenax* (Lindblom 1997) and *X. tenuiloba* are partly overlapping. They often grow together in the collections that I have seen from Baja California. The two species are very different from each other, and probably not closely related. *Xanthoria tenax* has a bright yellow, flattened, rosette-like thallus, that only possess a lower cortex under the outermost tips of rather fan-shaped lobes that does not produce any vegetative diaspores.

An apparently undescribed, shrubby, sorediate species of *Xanthoria* was recently discovered in California (Wright 2000). Compared to *X. tenuiloba*, it seems to have completely different soralia, which appear as wide ruptures that produce true soredia (blastidia in *X. tenuiloba*). In addition, it is constantly orange, apothecia are rare and the lobe structure is different.

Several of the genera in the Teloschistaceae have been considered artificial for a long time. The genus *Xanthoria* has been regarded as paraphyletic, shown by Kärnefelt (1989) in a cladistic analysis based on morphological characters. In recent phylogenetic analyses based on molecular data, *Xanthoria* does not come out as a monophyletic group (Arup & Grube 1999, Søchting & Lutzoni 2000). Therefore, changes at the genus level in the systematics of Teloschistaceae are a previewed result of ongoing molecular studies (Arup & Grube 1999, Søchting & Lutzoni 2000, Kondratyuk et al. 2000).

However, traditionally fruticose and subfruticose members of the family Teloschistaceae with prosoplechtenchymatic cortex have generally been referred to the genus *Teloschistes*, while those with paraplechtenchymatous cortex are placed in *Xanthoria*. Several fruticose species, known from the genus *Caloplaca* (Poelt & Pelleter 1984, Arup 1995b), and a new species, *C. erecta*, recently described from New Zealand (Arup & Mayrhofer 2000), represent different phylogenetic lineages according to their other characters. The species in the fruticose group of *Caloplaca* have a thallus that is crustose when juvenile, but soon develops a dwarf-fruticose habit with terete lobes.

Therefore, I have chosen to describe this species in the genus *Xanthoria* based on the habitus of the thallus, paraplechtenchymatous cortex anatomy, ellipsoid conidial shape, and related secondary chemistry. From my knowledge of the morphology in this genus, I would predict that *Xanthoria tenuiloba*, together with for example *X. candelaria* and *X. polycarpa*, is probably more closely related to the *X. parietina*/ *X. calcicola* branch than the *X. fallax* branch in the phylogenetic tree of Arup & Grube (1999). Molecular studies are underway to confirm the position of *X. tenuiloba* in *Xanthoria* s.str.

Additional specimens examined

MEXICO. BAJA CALIFORNIA. Bahia San Quintin (= c. 170 km S.S.E. of Ensenada on Pacific Coast), 10 m, 1966 *Santesson* 18350, 18369 (UPS). Cerro Kentin and adjacent area to the east, W of Bahia de San Quintin, 40 m, 30°28'N, 116°00'W, 1987 *Ryan* 21280 (ASU). Cerro Kenton between Bahia Falsa and Bahia San Quintin, 20-100m, 30°28'N, 116°00'W, 1989 *Moberg* 8657 (UPS), *Wetmore* 63568 (MIN), *Wetmore* 63615 (MIN, BG), *Clerc* 89/323 (G). 11 km N of El Rosario, Vizcaino Region of the Sonoran Desert, 100m, 30°08'21"N, 115°45'59"W, 1997 *Nash* 40170 (ASU, LD), *Wetmore* 79157 (MIN), *Westberg* 244 (LD). 10 km N of El Rosario in Cañon del Rosario, 90 m, 30°08'N, 115°46'W, 1989

Wetmore 63704 (MIN), *Clerc* 89/492 (G). Along route 1 on S side of Cañada el Aguajito and 10 km ESE of bridge over Arroyo El Rosario, Vizcaino Region of the Sonoran Desert, 250 m, 30°03'21"N, 115°34'56"W, 1998 *Wetmore* 79813 (MIN).

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STUDIES IN LICHENICOLOUS FUNGI AND LICHENS XII*: ON THE GENUS TREMATOSPHAERIOPSIS (DOTHIDEALES)

JOSEF HAFELLNER

Institut für Botanik, Karl-Franzens-Universität,
Holteigasse 6, A-8010 Graz, Austria.
Email: josef.hafellner@uni-graz.at

Abstract: The monotypic ascomycete genus *Trematosphaeriopsis* is reinvestigated and accepted as a separate genus. It is founded on the lichenicolous, gall-inducing species *Trematosphaeriopsis parmeliana*, which grows exclusively on *Xanthoparmelia* species. Originally known only from Asia, it is reported here also from Europe, Africa, North and South America.

Key words: Lichenicolous Ascomycotina, *Xanthoparmelia*, taxonomy

Introduction

Hyalophragmosporous, lichenicolous pyrenomycetes were formerly classified in *Sphaerulina* Sacc. when interthecial filaments are not present in mature ascomata, or *Metasphaeria* Sacc. when interthecial filaments persist in the perithecia or loculi. Vouaux (1913) accepts 10 lichenicolous species in *Sphaerulina* and 4 in *Metasphaeria* (of which only two are treated because of a severe printing error). Clauzade et al. (1989) mention 8 species in *Sphaerulina* and 2 in *Metasphaeria* in the respective keys.

In ongoing revisional work of hyalophragmosporous, lichenicolous pyrenomycetes it was shown that the lichenicolous species previously classified in *Metasphaeria* belong to other genera. Some species have been recognized as a phragmosporous lineage within the mainly didymosporous genus *Cercidospora* (Hafellner 1987), others are now classified in *Sagediopsis* (Triebel 1989), and for one species, after the recognition of arthonialean features, the genus *Perigrapha* Hafellner (Hafellner 1996) has been described.

Also hyalophragmosporous is *Trematosphaeriopsis parmeliana* (Jazq.) Elenkin, a widely distributed but often overlooked inhabitant of *Xanthoparmelia* species. Under the nomenclatural synonym *Homostegia parmeliana* (Jazq.) Vouaux, but based on an evidently misidentified specimen, the species recently has been reported from the U.S.A. (Cole & Hawksworth 2001: 314 - 316). In order to gain a correct concept of the genus *Trematosphaeriopsis* Elenkin and its type species *Trematosphaeriopsis parmeliana*, the taxon is reinvestigated and treated in some detail here.

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*XI in Herzogia 15 (in press).

Material and methods

Dried herbarium specimens have been used and these are cited below in the treatment of the species. External morphology was studied with a dissecting microscope (WILD M3, 6,4x - 40x); anatomical studies of the thallus and the ascomata were carried out with a light microscope (REICHERT POLYVAR, 40x - 1000x). Sectioning was performed with a freezing microtome (LEITZ, sections of 12 - 15 µm) but squash preparations were also used especially for ascus analysis. Preparations were mounted in water. When necessary, contrasting was performed by a pretreatment with lactic acid-cotton blue (MERCK 13741). Amyloid reactions in hymenia were observed by the use of Lugol's reagent (MERCK 9261). Conidiogenesis of pycnoconidia was studied in erythrosin B (ALDRICH 19,826-9) in 10% ammonia. Sections and squash preparations were not pretreated with KOH, unless otherwise stated. Measurements refer to dimensions in ordinary water.

Results

Trematosphaeriopsis Elenkin, Izv. Imp. S.-Peterburgsk. Bot. Sada 1: 146 (1901).

Species holotypica adhuc unica: *Trematosphaeriopsis parmeliana* (Jacz.) Elenkin (*Trematosphaeria parmeliana* Jacz.)

Trematosphaeriopsis parmeliana (Jacz.) Elenkin, Izv. Imp. S.-Peterburgsk. Bot. Sada 1: 146 (1901).

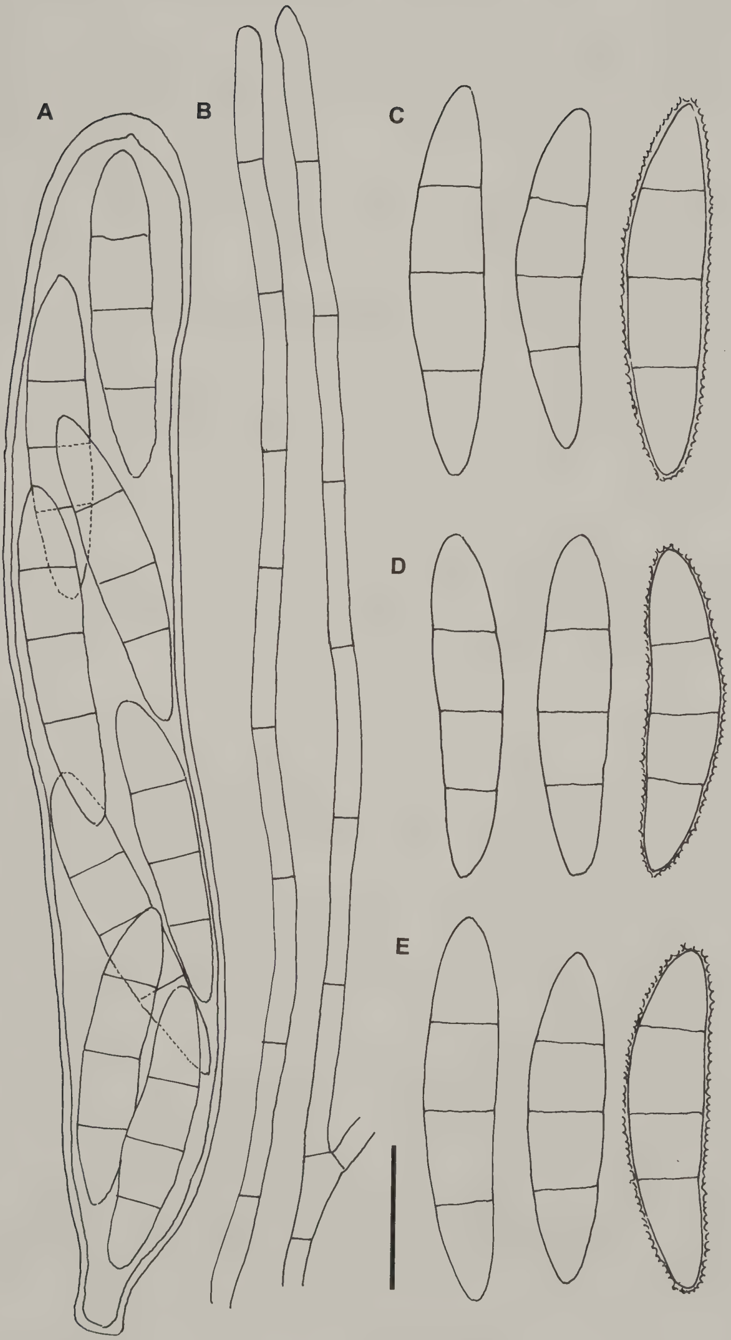
Bas.: *Trematosphaeria parmeliana* Jaczewsky in Elenkin, Trudy Imp. S.-Peterburgsk. Bot. Sada 19, Fasc. 1: 22 (1901).

Syn.: *Homostegia parmeliana* (Jacz.) Vouaux, Bull. Soc. Mycol. France 28: 198 (1912).

Typus: „Ad flumen Cherulun in desertis Mongoliae borealis, 1899, leg. Palibin" = Elenkin, Lich. Fl. Rossiae no. 6d, admixture in specimen of *Parmelia conspersa* ssp. *molliuscula* var. *vagans* (UPS - Isotypus!).

Icon: Elenkin 1901b: 136, Fig. 1, 137, Fig. 2 (habitus); 137, Fig. 3, 138, Fig. 4 (section through gall); 146, Fig. 5 (ascomata, asci, interthecial filament, ascospores); Bachmann 1929: 470, Fig. 12, 13, sub *Metasphaeria superveniens* (habitus); 473, Fig. 14 - 17 (section through gall); 474, Fig. 18 - 23 (section through gall, section through ascoma, asci, ascospores); Keissler 1930: 483, Fig. 91, sub *Metasphaeria superveniens* (Habitus); 486, Fig. 92, sub *Metasphaeria superveniens* (section through gall, section through ascoma, asci, ascospores); Fig. 1 in this publication (ascus, interascal filaments, ascospores).

Figure 1. *Trematosphaeriopsis parmeliana*. A, ascus, B, interascal filaments, C, ascospores (A-C Hafellner 23981), D, ascospores (Hafellner 41083), E, ascospores (Poelt 16.VII.1962). Rough perispore indicated on the spores to the right. Scale = 10 µm.


A
B
C
D
E

Infection inducing the formation of thalline galls. Galls hemisphaerical to somewhat flattened, on narrow lobed species of *Xanthoparmelia* also basally constricted, of the same colour as the host thallus or slightly paler; in longitudinal section galls contain many healthy algal cells inbetween and below the ascomata.

Ascomata perithecioid, about 10-20 per gall, entirely immersed and protruding only at the ostiole. Peridium hyaline throughout, only slightly brownish in the ostiolar region; peridial wall in section seen as small celled textura globosa intermingled with elongate elements. Hamathecium present as interthecial filaments and short filaments in the ostiolar region. Interthecial filaments mostly simple, about 2 µm thick. Asci fissitunicate, cylindrical, 8-spored, asci containing mature ascospores 70 - 85 (-90) x 11 - 15 µm. Ascospores three-septate, narrowly ellipsoid, hyaline, (22 -) 24 - 28 (- 31) x 4 - 6 (- 7) µm, with thin perispore. Mature to overmature ascospores with an external wall layer provided with tiny hyaline warts, this layer originating from the perispore, finally giving the spores a slightly yellowish appearance.

Microconidiomata common, also immersed in the galls, ovoid in section; pycnidial wall in section seen as samll celled textura globosa; conidiogenous cells lining the cavity, flask-shaped; microconidia produced terminally, bacillar, ca. 4 x 1 um.

Chemical reactions: Hymenial jelly J(Lugol) –, ascus wall J(Lugol) –.

Host spectrum: *Xanthoparmelia conspersa*, *X.* cf. *moctezumensis*, *X. vagans* (host of the type), *X. wildae*, *X.* spec.

Distribution: Europe: Austria, Germany (sec. Bachmann 1929), Italy. Asia: Mongolia. Africa: Canary Islands. North America: U.S.A., Mexico. South America: Venezuela

Remarks

Both the genus and the species has been widely ignored since its original description (in Elenkin 1901a, b). Eriksson & Hawksworth (1998) still supposed, *Trematosphaeriopsis* could be a later synonym of *Homostegia* Fuckel. This opinion dates back to Vouaux (1912), who had transferred *T. parmeliana* into the genus *Homostegia*, and also Clauzade et al. (1989: 48) treat the species in that genus.

Homostegia Fuckel is typified on *Homostegia piggotii* (Berk. & Broome) P.Karst., a lichenicolous species restricted to *Parmelia* s. str., which is well characterized by its pluriloculate stromata. Its ascospores are phragmosporous but dark brown at maturity. The main reasons for this transfer presumably were, that Elenkin (1901b, 1902) had interpreted the galls induced by the infection with *Trematosphaeriopsis parmeliana* as being stromata and that the colour of the ascospores was described as subhyaline to yellowish.

According to Elenkin (1901b) the diagnostic difference between *Trematosphaeria* and *Trematosphaeriopsis* should be the presence of a stroma of interwoven hyphae containing algal cells. This observation lead Elenkin (contrary to a correct interpretation in Elenkin 1901a) to the opinion, that the "stroma" was induced by the presence of algae (!), and therefore he called that biotic system a facultative lichen. The observation of the presence of algal cells in the galls in between the ascomata of the lichenicolous fungus is correct and confirmed by both Bachmann (1929) and our own observations, but Elenkin's interpretation of this three-biont-system sounds a little bit strange today.

Trematosphaeria Fuckel is not a closely related genus. *Trematosphaeria pertusa* (Fr.) Fuckel, the type species, is a non-specific inhabitant of decorticated wood of deciduous trees (cfr. Ellis & Ellis 1985: 40) with quite different features, e.g. pseudothecia with intensively pigmented peridial walls. At the time *Trematosphaeria* is placed in Melanommataceae (Dothideales or Melanommatales depending on the circumscription of the orders) (Eriksson & Hawksworth 1993).

The closest relative of *Trematosphaeriopsis* is probably *Cercidospora* Körb. with which it has in common the almost entirely unpigmented peridium of a textura intricata, the simple interthecial filaments, the subcylincridal fissitunicate asci, and the septate hyaline ascospores. However, the ascomata of *Cercidospora* species contain a bluish-greenish pigment in the ostiolar region of the peridial wall, which makes the ascomata visible under hand lens or the dissecting microscope as black dots, and the perispore of *Cercidospora* ascospores does not condense into warts. Therefore, *Trematosphaeriopsis* is best placed at the moment as a further genus in the Dothideales incertae sedis.

Generally, the type collection of *T. parmeliana* has been supposed to be the only known and published record. However, Bachmann (1929: 470 - 476) had in his hand the same species when studying in detail a collection gathered in the German Schwarzwald and what he thought to be "*Metasphaeria superveniens*" on "*Parmelia conspersa*". His observations together with the figures definitely do not describe "*Metasphaeria superveniens*". His figures have been republished under the same name by Keissler (1930: 483, 486, Fig. 91, 92) giving raise to a misunderstanding of "*Metasphaeria superveniens*" for long time. With the knowledge of today it is evident that Bachmann had studied *Trematosphaeriopsis parmeliana*, a fungus specific to *Xanthoparmelia*, and not the arthonialean *Perigrapha superveniens* (Nyl.) Hafellner, a species restricted to *Parmelia* s. str. (cfr. Hafellner 1996).

On the other hand, Cole & Hawksworth (2001) recently supposed to have found *Trematosphaeriopsis parmeliana* (published under the name *Homostegia parmeliana*) on *Flavoparmelia caperata* in North America. But with the characters mentioned (e.g. ascospores becoming dark brown at maturity) it is clear, that that fungus represents a different species, possibly a further taxon of *Homostegia* rather than one of *Trematosphaeriopsis*.

Ascospore size is somewhat variable in *Trematosphaeriopsis parmeliana*, which is not astonishing, as the fungus has a very wide distribution and can infest *Xanthoparmelias* in a range of habitats. The spore size given by Elenkin (30 x 6 - 8 µm, sec. Elenkin 1901a: 22, 1901b: 146) is close to the upper limit. Considerably smaller ascospores have been found in collections from other regions of the world, but the spore shape, the septation, and the presence of a perispore condensing into small warts are constant features.

Further specimens seen (all specimens identified by the author, some separated from *Xanthoparmelia* collections in GZU): **Europe**: **Austria**. Steiermark, Gurktaler Alpen, Frauenalm S von Murau, S-exponierte Abbrüche zwischen

Oberberg und Frauenalm, ca. 1700 m; über kalkhaltigem Schiefer, auf *Xanthoparmelia conspersa* (th.); 26. VI. 1983, J. Poelt (GZU). - **Italy**. Südtirol: Ortler Gruppe, am Eingang in das Martelltal bei Morter, ca. 800 m; auf einem Gneisblock, auf *Xanthoparmelia conspersa* (th.); 15. VII. 1962, J. Poelt (GZU). - **Asia**: **Mongolia**. SE Changai, W vom Somonzentrum Bwen, am Wege Richtung Bajan-Ondor; auf *Xanthoparmelia vagans* (th.); Ende VI. 1974, W. Hilbig & Schamsran (herb. Hafellner 23981). - **Africa**: **Canary Islands**. Gran Canaria. An der Straße von Valleseco nach Artenara, ca. 2 km E von Los Pinos de Galdar, ca. 1400 m, 28°02'N/15°36'30"W; Lavablockfeld, N-seitig auf Lavablöcken, auf *Xanthoparmelia conspersa* (th.); 23. II. 1994, J. Hafellner no. 47791 (GZU). - **North Amerika**: **U.S.A.**: **Virginia**. Page Co., Shenandoah National Park, Skyline Drive S of Thornton Gap, Pinacles Picnic Ground, 1000 m, on *Xanthoparmelia conspersa* (th.); 13. IX. 1977, J. Hafellner no. 2809 (herb. Hafellner). - **Arizona**. Coconino Co., Grand Canyon National Park, north slopes along Grand View Trail below Grand View Point, ca. 2000 m, 36°00'N/111°59'W; rocky slope with scattered trees of *Pinus edulis*, on cliffs of siliceous sandstone, on *Xanthoparmelia conspersa* (th.); 10. VII. 1994, J. Hafellner no. 41083 (herb. Hafellner). - **Mexico**: **Chihuahua**. Sierra Madre Occidental, Sierra La Catarina SSE of Nuevo Casas Grandes, W of Ignacio Zaragoza, ca. 2240 m, 29°46'30"N/107°37'25"W; open pine-juniper-oak forest on steep slope, on volcanic boulders exposed to the S, on *Xanthoparmelia* spec. (th.); 19. VII. 1994, J. Hafellner no. 37488 (herb. Hafellner). - **Sonora**. 3 km SE of Moctezuma, ca. 680 m, 29°47'N/109°37'W; lava field in open shrubland, on volcanic boulders, on *Xanthoparmelia* cf. *moctezumensis* (th.); 9. II. 1993, J. Hafellner no. 37608 & A. Hafellner (GZU, to be distributed in Santesson, Fungi Lichenicoli exs.). - **South Amerika**: **Venezuela**. **Estado Merida**: Anden, an der Straße Merida - Valera, zwischen San Rafael und Mucuchies, ca. 2950 m, über verbackener Erde an steiler, ca. 2 m hoher Straßenböschung, S- und E-exponiert, auf *Xanthoparmelia wildae* (th.); 16. IV. 1969, H. Hertel, B. Oberwinkler & F. Oberwinkler (GZU).

It is an interesting fact that taxa of Parmeliaceae are inhabited by a number of cecidogenous lichenicolous fungi pertaining to a range of taxonomic groups. The most conspicuous galls are induced by infections with heterobasidiomycetes (e.g. *Biatoropsis usnearum* Räsänen, *Syzygospora parmeliicola* Diederich, *Tremella everniae* Diederich, *T. parmeliarum* Diederich), members of Arthoniales (e.g. *Perigrapha superveniens*), Lecanorales (e.g. *Phacopsis vulpina* Tul., *Nesolechia oxyspora* (Tul.) A.Massal. (syn. *Phacopsis oxyspora*)), and Dothideales (*Trematosphaeriopsis parmeliana*).

Acknowledgements
The author thanks Prof. Dr R. Santesson for hints on type material of *Trematosphaeriopsis parmeliana*, Dr R. Moberg and Dr L. Tibell for making possible herbarium studies in Uppsala (UPS), and Dr B. Coppins for reading critically the manuscript.

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CETRARIOID LICHENS CONTAINING USNIC ACID FROM THE TIBETAN AREA*

TIINA RANDLANE and ANDRES SAAG
Institute of Botany and Ecology, University of Tartu,
Lai Street 38, 51005 Tartu, Estonia
E-mail: randlane@ut.ee

WALTER OBERMAYER
Institut für Botanik, Karl-Franzens-Universität Graz,
Holteigasse 6, A-8010 Graz, Austria
E-mail: walter.obermayer@kfunigraz.ac.at

ABSTRACT: A floristic survey of the yellow cetrarioid lichens containing usnic acid (fam. Parmeliaceae, lichenized Ascomycota) which are found in Tibet and neighbouring areas is presented. Typical characters, chemical constituents and distribution data are reported for all 26 species from seven genera (*Allocetraria, Cetraria, Cetreliopsis, Flavocetraria, Nephromopsis, Tuckneraria* and *Vulpicida*). Complete descriptions are provided for several taxa which have not been included in recent reviews of the cetrarioid genera. Two identification keys for taxa – both at generic and species level – have been compiled. Worldwide distribution maps are presented for the first time for some *Allocetraria*, *Cetraria, Cetreliopsis* and *Tuckneraria* species.

INTRODUCTION

The family Parmeliaceae consists of nearly 90 genera and more than 2000 species (Hawksworth *et al.* 1995; Tehler 1996). The largest parmelioid genus, *Xanthoparmelia*, is primarily distributed in the southern hemisphere, and several other species rich parmelioid genera are considered to have their centers of speciation or distribution in either South America, Australia or southern Africa – including *Bulbothrix*, *Hypotrachyna*, *Flavoparmelia*, *Paraparmelia*, *Punctelia, Rimelia* etc. (Elix 1993). Many cetrarioid genera, on the contrary, are mainly (e. g. *Platismatia*, *Tuckermannopsis*) or only (e.g. *Ahtiana*, *Allocetraria*, *Asahinea*, *Vulpicida*) distributed in the northern hemisphere. Such cetrarioid taxa as *Cetrelia*, *Cetreliopsis*, *Nephromopsis*, *Tuckneraria* evidently have their centers of speciation in eastern or southeastern Asia. The Tibetan area is one of the regions where the cetrarioid lichen flora is extremely prolific.

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* Lichenological results of the Sino-German Joint Expedition to south-eastern and eastern Tibet 1994. VI.

The aim of the present paper is to survey one of the most distinctive morphological groups of Parmeliaceae – the yellow cetrarioid species – in the Tibetan area. Although most lichenologists can readily distinguish parmelioid and cetrarioid lichens as well as identify the presence of usnic acid in the thallus, the precise identification of the yellow cetrarioid lichens is not as simple. For example, 10 such species were reported from the province Xizang, China relatively recently (Wei & Jiang 1986; Wei 1991), but today 20 yellow cetrarioid species from various genera are known from this region. Six* further species (*Allocetraria endochrysea, 'Cetraria' leucostigma, Nephromopsis komarovii, N. ornata, N. stracheyi, Vulpicida juniperina*) can now be added to this list as they have been collected from neighbouring territories. To promote the knowledge of these rare and beautiful lichens, two keys (for the identification of taxa both at generic and at species level) have been compiled. They include 26 taxa containing usnic acid from seven cetrarioid genera (*Allocetraria, Cetraria, Cetreliopsis, Flavocetraria, Nephromopsis, Tuckneraria* and *Vulpicida*). The numerous keys which have been published previously enable one to identify taxa at the species level, whereas determining the correct genus has often been a problem. The keys presented in this paper should avoid this deficiency. Complete descriptions have been provided for several taxa which have not been included in recent reviews of cetrarioid genera (Kärnefelt & Thell 1996; Kärnefelt *et al.* 1994; Mattsson 1993; Randlane & Saag 1998; Randlane *et al.* 1994, 1995; Thell *et al.* 1995). For other species literature descriptions are referenced while chemical and distributional data are reported in full, usually with some additions to the published data. Worldwide distribution maps are presented for the first time for some *Allocetraria, Cetraria, Cetreliopsis* and *Tuckneraria* species.

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* One more species probably belonging to the group of yellow cetrarioid lichens – *Nephromopsis hengduanensis* L. H. Chen – has been described just recently from China, Yunnan province (Chen & Gao 2001). We are not sure about the generic position of this new species as the original description of the taxon reveals the state of some essential characters as very unusual for the indicated genus (ascospores extremely large, pycnoconidia bifusiform till filiform, pseudocyphellae present both on the upper and lower surfaces, thallus occasionally ciliate). We decided not to include *N. hengduanensis* in the present survey before the type material of this taxon is available for further studies.

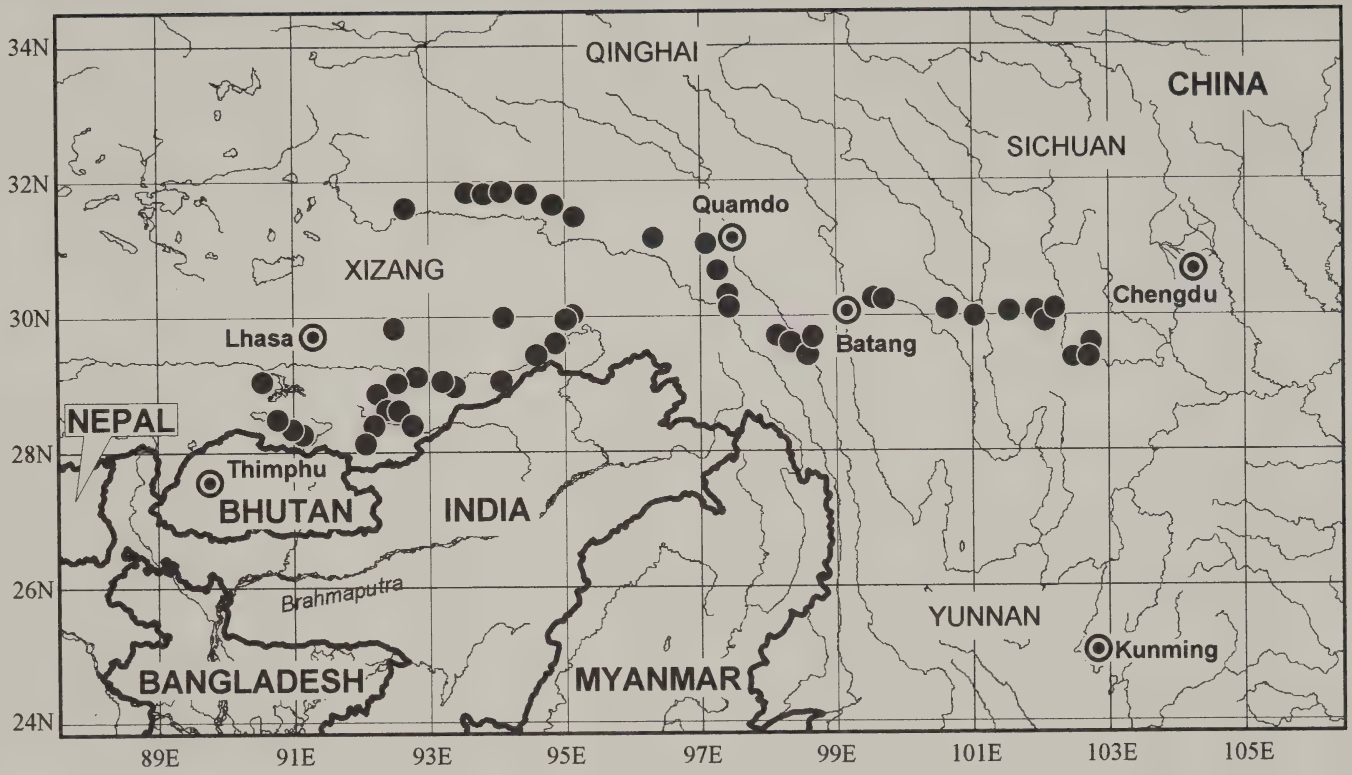
QINGHAI
CHINA
SICHUAN
Quamdo
XIZANG
Chengdu
Lhasa
Batang
NEPAL
Thimphu
BHUTAN
INDIA
Brahmaputra
YUNNAN
Kunming
BANGLADESH
MYANMAR
34N
32N
30N
28N
26N
24N
89E
91E
93E
95E
97E
99E
101E
103E
105E

Fig. 1. Location of collection sites of the Sino-German Joint Expedition to Tibet 1994.

MATERIAL AND METHODS

The basic material for the present work comprised approximately 90 specimens which were collected by the third author and his colleagues Georg and Sabine Miehe, Ubbo Wündisch, Achim Bräuning and Bernhard Dickoré during the Sino-German Joint Expedition to south-eastern and eastern Tibet in 1994 (Fig. 1). Additionally, several other collections from the Tibetan area and its surrounding mountain-systems, which are housed in B, BM, COLO, FH, GZU, H, LD, S, STU, TU, UPS and US, have been included. Historically an extensive mountainous area in southern Asia (which at present is divided between China, India, Nepal, Bhutan, Myanmar) is called Tibet. According to the official administrative arrangement, Tibet is defined as Xizang province of China (Wei 1991). To present the list of Tibetian yellow cetrarioid lichens, we have included all the species that had been reported from Xizang, and added the taxa known from neighbouring areas (including Qinghai, Sichuan, Xinjiang and Yunnan provinces of China; Nepal, Bhutan and north-eastern areas of India).

Microscopic studies were conducted with light microscopes Carl Zeiss Technival 2 and Olympus CH40. Chemical analyses were carried out according to the standardized TLC methods (Culberson & Kristinsson 1970; Culberson 1972; Culberson *et al.* 1981). The acetone extracts were run in solvent systems C and G.

Distribution maps were compiled using the computer program DMAP; both literature data and localities of herbarium specimens examined were included.

The following abbreviations for collectors have been used in the location lists:
A.B. = Achim Bräuning; B.D. = Bernhard Dickoré; U.K. = U. Kirschbaum; V.K. = Vera Komarkova; G. & S.M. = Georg & Sabine Miehe; W.O. = Walter Obermayer; J.P. = Josef Poelt; U.W. = Ubbo Wündisch.

RESULTS

Key to the genera of yellow cetrarioid lichens from the Tibetan area and adjacent regions

1. Medulla bright yellow (pinastric and vulpinic acids) .... *Vulpicida*
– Medulla white, pale yellow or orange (various medullary substances may be present but pinastric and vulpinic acids are absent)................. 2
2. Cross sections of the thallus branches more or less radially symmetric .... *Allocetraria* (p.p.)

- Thallus distinctly dorsiventral (although the lobes may be canaliculate or subtubular)......3

3. Lobes rather narrow, 2–8 (10) mm wide, and/or elongate. Pycnoconidia either filiform (10–19 x 0.5–2 µm) or bifusiform (5–6 x 1 µm). Mainly growing on soil, a few species corticolous........4

- Lobes usually wider, 8–15 (30) mm, not elongate. Pycnoconidia always bifusiform (4–5 x 1–2 µm). Mainly corticolous, one species epilithic......7

4. Pycnoconidia filiform (10–19 x 0.5–2 µm). Apothecia (if present) contain globose (7–10 µm in diam) to subglobose (6–9 x 5–7 µm) ascospores...... *Allocetraria* (p.p.)

- Pycnoconidia bifusiform (5–6 x 1 µm). Apothecia usually absent, if present – containing ellipsoid ascospores......5

5. Thallus sorediate, attached to the substrate. Medulla Pd + orange...... *'Cetraria'* (p.p.)

- Thallus not sorediate, erect or suberect. Medulla Pd –......6

6. Distinct pseudocyphellae present on the lower surface or on both surfaces...... *'Cetraria'* (p.p.)

- Pseudocyphellae on the lower surface very indistinct, or totally absent...... *Flavocetraria*

7. Pseudocyphellae present on both surfaces, medulla Pd + red (protocetraric and fumarprotocetraric acids)...... *Cetreliopsis*

- Pseudocyphellae present on lower surface only, medulla Pd – 8

8. Ascospores globose (7–10 µm in diam) to subglobose (6–9 x 5–7 µm) or thallus sorediate...... *Tuckneraria*

- Ascospores ellipsoid (6–12 x 3–7 µm). Soredia not present...... *Nephromopsis*

Key to the species of yellow cetrarioid lichens from the Tibetan area and adjacent regions

1. Corticolous or lignicolous......2

- Terricolous or epilithic......18

2. Thallus sorediate......3

- Thallus not sorediate......6

3. Soredia and medulla bright yellow...... *Vulpicida pinastri*

- Medulla white, soredia white or very pale yellow......4

4. Lower surface with small pseudocyphellae...... *Tuckneraria laureri*

- Lower surface without pseudocyphellae......5

5. Medulla Pd –...... *Allocetraria oakesiana*

- Medulla Pd + orange...... *Cetraria xizangensis*

6. Thallus isidiate .... *Allocetraria isidiigera*
– Thallus not isidiate 7
7. Medulla bright yellow (pinastric and vulpinic acids) .... *Vulpicida juniperina*
– Medulla white, pale yellow or orange (various medullary substances may be present but pinastric and vulpinic acids absent) 8
8. Lobes rather narrow, 2–8 (10) mm wide. Ascospores globose (7–10 µm in diam) or subglobose (6–9 x 5–7 µm) 9
– Lobes usually wider, 8–15 (30) mm. Ascospores ellipsoid (6–12 x 3–7 µm) 12
9. Marginal cilia may be present. Pycnoconidia bifusiform (5 x 1–1,5 µm) .... *Tuckneraria ahtii*
– Marginal cilia always absent. Pycnoconidia filiform (10–19 x 0.5–2 µm) ... 10
10. Lower surface pale yellow .... *Allocetraria ambigua*
– Lower surface pale brown, brown or black 11
11. Thallus usually fertile. Medulla Pd – .... *Allocetraria globulans*
– Thallus usually sterile. Medulla Pd + red (fumarprotosetraric acid) .... *Allocetraria flavonigrescens*
12. Pseudocyphellae on both surfaces. Medulla Pd+ orange (protocetraric and fumarprotocetraric acids) .... *Cetreliopsis asahinae*
– Pseudocyphellae on lower surface only. Medulla Pd – 13
13. Medulla pale yellow, K + deep yellow (secalonic acids) .... *Nephromopsis ornata*
– Medulla white, K– 14
14. Apothecia small and numerous, mainly laminal .... *Nephromopsis pallescens* var. *pallescens*
– Apothecia of various size and number, mainly marginal 15
15. Lower surface black, only margins brown to pale brown .... *Nephromopsis morrisonicola*
– Lower surface brown to whitish throughout 16
16. Medulla C + red (olivetoric or anziaic acid) ..... *Nephromopsis stracheyi*
– Medulla C – 17
17. Lower surface remarkably rugose, pseudocyphellae on ridges and plug-like outgrowths. Pycnidia numerous, on emergent projections .... *Nephromopsis yunnanensis*
– Lower surface smooth or moderately rugose, pseudocyphellae either on the surface or on ridges but not on special outgrowths. Pycnidia absent or marginal and immersed 18
18. Thallus moderately rugose, often with secondary marginal lobules. Pseudocyphellae small and flat, mainly developed on ridges .... *Nephromopsis laii*
– Thallus smooth or slightly wrinkled, without secondary marginal lobes. Pseudocyphellae medium to large, flat or concave, developed on the surface .... *Nephromopsis nephromoides*

19. Epilithic .... *Nephromopsis komarovii*
– Terricolous 20
20. Cross sections of the thallus branches more or less radially symmetric 21
– Thallus distinctly dorsiventral (although the lobes may be canaliculate or subtubular) 23
21. Thallus branches always radially symmetric, slightly inflated, becoming arachnoid or even partly hollow to the center 22
– Thallus irregular, may be radially symmetric or dorsiventral in the same specimen, medulla compact .... *Allocetraria stracheyi*
22. Medulla yellow to orange (hybocarpone). Pycnidia emergent .... *Allocetraria endochrysea*
– Medulla white. Pycnidia immersed or very slightly emergent .... *Allocetraria madreporiformis*
23. Lobes strongly canaliculate or subtubular; yellow on both surfaces, with reddish basal parts .... *Flavocetraria cucullata*
– Lobes plane, slightly convex or concave but not strongly canaliculate or subtubular; upper surface yellow to brown, lower surface yellow to black, basal parts not reddish 24
24. Thallus pale yellow on both surfaces, with dark yellow basal parts. Lobes foveolate and strongly wrinkled (especially on the upper side) .... *Flavocetraria nivalis*
– Thallus yellow to brown (may be black on the lower surface), basal parts not differently coloured. Lobes rather smooth 25
25. Medulla Pd + red (fumarprotocetraric acid) .... *Allocetraria flavonigrescens*
– Medulla Pd – 26
26. Lower surface uniformly brown, with pseudocyphellae forming a continuous white line along the margins on the lower side .... *Allocetraria sinensis*
– Lower surface either yellow or brown. Pseudocyphellae (if present) different 27
27. Lobes rather narrow (1–4 mm wide). Pseudocyphellae absent or present marginally in the form of small indistinct white dots 28
– Lobes wider (up to 8 mm). Pseudocyphellae always present (on the lower side only or on both surfaces), distinct, laminal, in the form of oval or rounded wide spots 29
28. Lobes more or less convex on the upper side. Medulla white or coloured .... *Allocetraria stracheyi*
– Lobes distinctly concave on the upper side – especially terminally. Medulla white .... *Allocetraria ambigua*

29. Upper surface yellow, lower surface brown. Pseudocyphellae white and very distinct; present on the lower side of the thallus .... *'Cetraria' leucostigma*
– Upper surface yellow, lower surface yellow or brown. Pseudocyphellae grey, surrounded by a distinct dark line; always present on the lower side but may also occur on the upper side............ .... *'Cetraria' melaloma*

The species

Allocetraria ambigua **(Bab.) Kurok. & M. J. Lai**

Bull. Natl. Sci. Mus. Tokyo, Ser. B, 17: 62, 1991. – *Cetraria ambigua* Bab., Hooker's J. Bot. Kew Gard. Misc. 4: 244, 1852. – Type: [India] Bompras, Garhwal, on wood and mosses, alt. 16 000 ft., *R. Strachey & E. Winterbottom*, Himalayan Herb., no. 6 (BM! – lectotype).

Description – see Thell *et al.* (1995).

Typical characters. Thallus dorsiventral, pale yellow on both surfaces. Lobes elongate, rather narrow (up to 4 mm wide) and distinctly concave on the upper side. Medulla white.

Chemical constituents. Contains usnic acid in the cortex; lichesterinic-protolichesterinic type fatty acids in the medulla. Secalonic acids A and/or C have been detected in several specimens (Thell *et al.* 1995).

Notes. The species might be confused with *Flavocetraria nivalis*, or more often with *Allocetraria stracheyi*, as all three taxa may grow together. *A. ambigua* is distinguished morphologically by the thin pale yellow thallus with elongated lobes which are usually clearly concave, especially near the apices of lobes. Unlike *F. nivalis* the upper surface of the thallus is rather smooth and not foveolate. If still in doubt, the shape of the pycnoconidia should be checked (filiform in *Allocetraria* and bifusiform in *Flavocetraria*). For the differences between this species and *A. stracheyi* see under the latter.

Distribution and habitat. Occurs mainly in the Himalayas, including China (Qinghai, Shaanxi, Sichuan and Xizang provinces), India (Awasthi 1983) and Nepal (Kurokawa 1993) (Fig. 2). Grows on soil (rarely at the base of small shrubs) in alpine meadows at altitudes of 2800–5600 m.

Selected specimens examined from Tibet and/or neighbouring areas. **CHINA. PROV. QINGHAI.** Mountains SE of village He Ka, 100 km S of Koko Nur (Qinghai Lake), 35°49'N 99°50'E (nos 277–289), 4000 m alt., lower to middle alpine belt, 26./27.VIII.1985, V.K. 285 (GZU). – On the SE slope of Mt. Kan She Ka, Leng Long Ling, 37°36'N 102°15'E, Nan Shan, Kun Lun Shan, NE of the Haibei Research Station (nos 27–36, 223–252), 4000–4500 m alt., upper alpine belt, 19./20.VII.1985, V.K. 30; 32–34; 225-1; 225-2; 228; 229; 233-2; 234; 235-2; 247; 249 (GZU). – **PROV. SICHUAN.** Shalui Shan Mts., 40 km NNE of Batang, SE of Yidun, 30°14'N 99°34'E, 4700–4850 m alt., alpine meadows with *Kobresia* and *Rhododendron* shrubs, on soil, 28.VI.1994, W.O. 03518; 03519-1 (GZU). – Shalui Shan Mts., 35 km NNE of Batang, SE of Yidun, 30°16'N 99°28'E, 4200–4300 m alt., pasture with schist outcrops and single

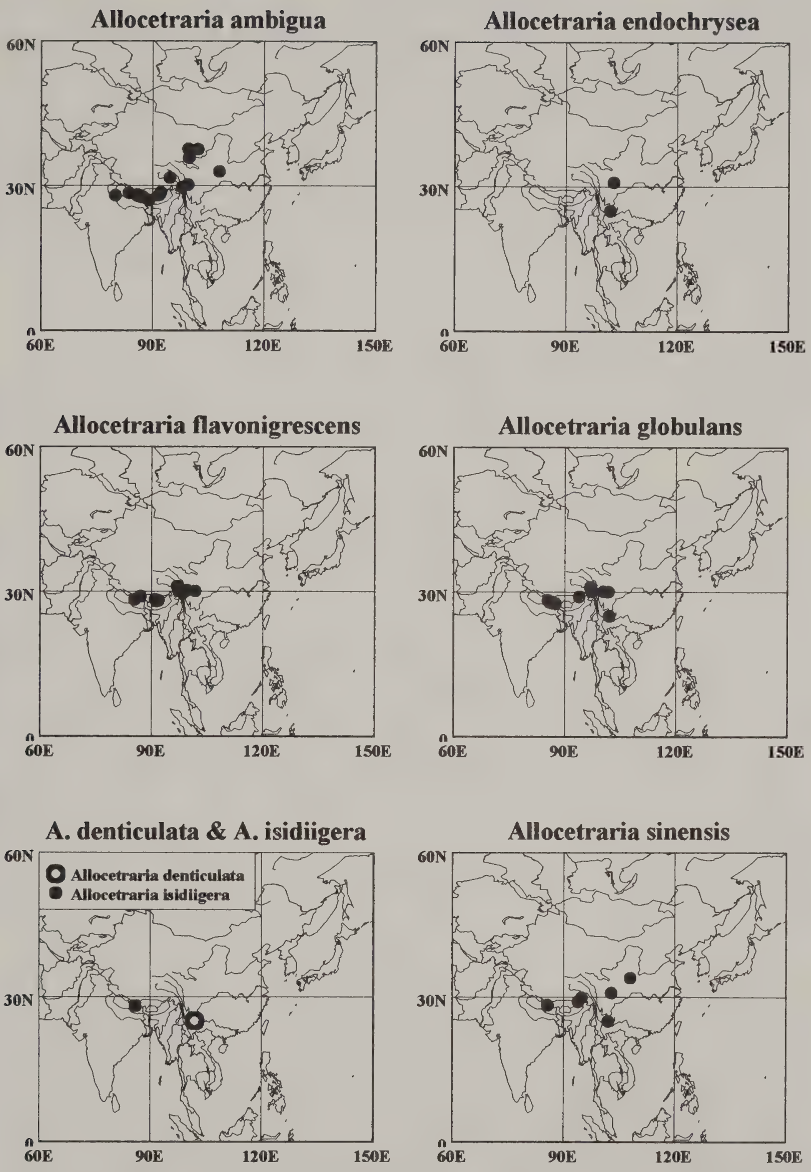
Allocetraria ambigua
Allocetraria endochrysea
Allocetraria flavonigrescens
Allocetraria globulans
A. denticulata & A. isidiigera
○ Allocetraria denticulata
● Allocetraria isidiigera
Allocetraria sinensis
60N
30N
0
60E
90E
120E
150E

Fig. 2. World distribution of *Allocetraria* species (I).

Juniperus trees, on soil, 27.VI.1994, W.O. 03494 (GZU). – **PROV. XIZANG.** Taniantaweng Shan Mts., 60 km W of Markam (=Gartok), pass 15 km NE of Zogang (=Wangda), 29°43'N 98°00'E, 4950–5010 m alt., on soil, 4.VII.1994, W.O. 03812a (GZU). – Tanggula Shan, way from Quamdo (=Changtu) to Nagqu (=Nakchu), 31°40'N 94°40'E, 4850 m alt., on soil, 9.VII.1994, W.O. 04137 (GZU). – Himalaya Range, 170 km SE of Lhasa, 80 km SE of Tsetang (Nedong), 2nd pass on way from Tsetang to Lhünze, 28°38'N 92°14'E, 5000 m alt., alpine meadows and debrise cones, on ground, 25.VII.1994, W.O. 04941 (GZU). – Himalaya Range, 190 km SSE of Lhase, 125 km S of Tsetang (Nedong), 20 km S of Nera Tso (=Ni la Hu), on way to Cona (=Tsona), 28°07'N 91°55'E, 4650–4800 m alt., alpine meadows, on ground and *Rhododendron*, 30.VII.1994, W.O. 05061b (GZU). – Himalaya Range, mountain directly southwest above Nyalam, 28°09'N 85°58'E (nos 362–384), 4000–4770 m alt., lower to upper alpine belt, on soil, 5./6.VII.1986, V.K. 369; 370-3; 371 (GZU). – **NEPAL.** Annapurna, rocks in the middle of North-Annapurna glacier, 5335 m alt., 6.IX.1979, V. Komarkova (COLO).

***Allocetraria endochrysea* (Lynge) Kärnefelt & A. Thell**

Nova Hedwigia 62: 507, 1996. – *Dactylina endochrysea* Lynge, Skr. Svalbard Ishavet (Oslo) 59, Suppl. 5: 62, 1933. – Type: China, Yunnan, Mt. Li Kiang, alt. 4 000 m, 1886, *R. P. Delavay* (H-NYL 35806 – holotype, O – isotype).

Description – see Kärnefelt & Thell (1996).

Typical characters. Thallus radial symmetric, slightly inflated, becoming arachnoid in the center. Medulla coloured (deep yellow to orange). Pycnidia emergent.

Chemical constituents. Contains usnic acid in the cortex and hybocarpone and secalonic acid B in the medulla. Literature data about medullary compounds are various – Follmann *et al.* (1968) mention dufourin and endochrysin; Kärnefelt & Thell (1996) add lichesterinic and protolichesterinic acids. The latest HPLC analysis by Elix established that in addition to usnic acid, hybocarpone (major) and secalonic acid B (minor) were present in our Tibetan specimen. Hybocarpone is a novel cytotoxic naphthazarin derivative which was recently described from *Lecanora hybocarpa* (Tuck.) Brodo (Ernst-Russell *et al.* 1999). Endochrysin is probably an older name for the complex of secalonic acids. Chemical structure and position of dufourin is uncertain (Culberson 1970).

Notes. The taxon was originally described by Lynge (1933) as a *Dactylina* because of its morphological similarity to *D. madreporiformis*. Both species were transferred to *Allocetraria* by Kärnefelt & Thell (1996), mainly on the basis of a very distinctive type of filiform pycnoconidia and the medullary chemistry. Apothecia have not previously been observed. Our single specimen was fertile; apothecia terminal, c. 2–5 mm in diameter, with a brown disc and rather thick thalline margin; mature asci not found. The species can be separated from *A. madreporiformis* by the coloured medulla.

Distribution and habitat. Endemic to the Himalayas; has been found in China in Sichuan and Yunnan provinces (Follmann *et al.* 1968; Wei 1991;

Kärnefelt & Thell 1996) (Fig. 2). Not recorded from Tibet but most probably occurs there. Grows on soil at altitudes of 4000–4700 m.

Specimens examined from Tibet and/or neighbouring areas. **CHINA**. **PROV. SICHUAN.** Southern Qionglai Shan, E of Chengdu, pass W of Wolong, 30°55'N 102°56'E, 4450 m alt., alpine mats with frost heaves, on ground, 9.X.1994, G. & S.M. and U.W. 94-546-32A2 (GZU).

***Allocetraria flavonigrescens* A. Thell & Randlane**

in Daniels *et al.* (eds), Flechten Follmann: 359, 1995. – Type: Nepal, Langtang, Pemdang Karpo, SW exposed rocks, on *Juniperus*, 29.09.1986, *G.M. & S. Miehe 13 056* (GZU! – holotype).

When this taxon was described some years ago (Thell *et al.* 1995) only sterile material (two specimens) was available and neither pycnoconidia nor ascospores had been observed. It was placed in *Allocetraria* on the basis of general morphology and the anatomy of the cortices. Now a number of additional specimens have been identified and the original description can be complemented with the details of the fruiting bodies.

Descripton. Thallus dorsiventral, subfruticose to foliose, suberect to prostrate, up to 6 cm wide, irregularly branched; lobes narrow to medium size, mainly convex, 1–5 mm wide; upper surface usually pale yellow, sometimes greenish or brownish yellow; lower surface dark brown to black, occasionally pale brown at the apices of lobes; rhizines absent or sparse, situated marginally or laminally on the lower surface; pseudocyphellae absent. Apothecia rare, marginal to submarginal, with a brown disc up to 15 mm wide; thalline margin rather thick and crenulate, pale yellow; asci subcylindrical or narrowly clavate, 30–42 x 9–12 μm; ascospores globose, 4–5 μm in diameter. Pycnidia marginal to laminal, black, immersed or more often on short projections, sometimes in clusters; pycnoconidia filiform, 13–17 x 1–1.5 μm.

Typical characters. Thallus dorsiventral, upper surface yellow, lower surface dark brown to black. Pseudocyphellae absent. Contains fumarprotocetraric acid in the medulla, Pd + red.

Chemical constituents. Contains usnic acid in the cortex; fumarprotocetraric acid (major), protocetraric acid (minor) and an unknown fatty acid (neither lichesterinic-protolichesterinic type nor caperatic acid) in the medulla. An unidentified violet pigment is also occasionally detected.

Notes. This recently described species is not rare in Tibet – we have examined *ca.* 20 specimens. *A. flavonigrescens* is characterized by the positive Pd reaction and until recently was considered the only species in the genus *Allocetraria* which contained fumarprotocetraric acid. Investigation of the type material of *A. isidiigera* has now showed that this species also contains fumarprotocetraric acid in the medulla. However, the latter taxon is readily distinguished from *A. flavonigrescens* by the presence of sparse isidia. In our opinion, the isidia and isidia-like stuctures in *A. isidiigera* are ill-defined and not a definitive character and suggest that *A. isidiigera* and *A. flavonigrescens* are very closely allied taxa. Their possible conspecific status probably cannot be verified by morphological-chemical studies alone but molecular methods should solve this problem.

Distribution and habitat. Endemic to the Himalayas: in Nepal (Thell *et al.* 1995) and in China (Sichuan and Xizang provinces) (Fig. 2). Grows on soil at altitudes of 4200–5300 m, occasionally also on twigs of *Juniperus* and *Rhododendron*.

Specimens examined from Tibet and/or neighbouring areas. **CHINA. PROV. SICHUAN.** Shalui Shan Mts., 40 km NNE of Batang, SE of Yidun, 30°14'N 99°34'E, 4700–4850 m alt., alpine meadows with *Kobresia* and *Rhododendron* shrubs, on soil, 28.VI.1994, W.O. 03517; 03519-3; 03521 (GZU). – ibid., first pass between Kangding (Dardo) and Litang, 30°05'N 101°48'E, 4300 m alt., alpine meadows with *Kobresia pygmaea*, 23.VI.1994, W.O. 03106 (GZU). – **PROV. XIZANG.** Karo La Pass E of Gyantse, on the road towards Lhasa, in the mountains of Ninjin Kanshan (nos 303–354), 5000–5600 m alt., middle to upper alpine belt, 28.VI.–1.VII.1986, V.K. 311 (GZU). – Himalaya Range, 170 km S of Lhasa, between Lhozhag and Lhakhang Dzong, W-facing slopes of Dhalari mountain, 28°20'N 90°58'E, 4300 m alt., NNW-exposed, underhang, on mosses on rock, 20.VII.1994, W.O. 04501 (GZU). – Himalaya Range, 190 km SSE of Lhase, 125 km S of Tsetang (Nedong), 20 km S of Nera Tso (=Ni la Hu), on way to Cona (=Tsona), 28°07'N 91°55'E, 4650–4800 m alt., alpine madows, on ground, 30.VII.1994, W.O. 05107 (GZU). – Tibetan Himalaya, Everest E, head Kangchung Gl., 13 km E of Everest top (Camp Ev8), 28°59'N 87°02'E, 5280 m alt., upper alpine *Kobresia pygmaea-Festuca* turf, on cushions, open moraine sand, among gneiss boulders, 16.X.1989, B.D. K-63-8a; K-63-8c (GZU). – ibid., ascent Karpo La S, 29°00'N 87°02'E, 5740 m alt., subniv., highest scree plants on ridge, gneiss boulders, on ground, 17.X.1989, B.D. K-65-1 (GZU). – Tanggula Shan, way from Quamdo (=Changtu) to Nagqu (=Nakchu), 31°05'N 96°56'E, 4800 m alt., pass-area, on soil, 8.VII.1994, W.O. 04054; 04069 (GZU). – 120 km SSW of Quamdo (=Changtu), 10 km S of Bamda, 30°09'N 97°17'E, 4500–4700 m alt., on ground, 6.VII.1994, W.O. 03965 (GZU). – ibid., *Rhododendron* shrubs, on soil and *Rhododendron*, 5.VII.1994, W.O. 03869 (GZU). – Ningjing Shan Mts., 9 km W of Markam (=Gartog), 29°40'N 98°32'E, 4200–4400 m alt., *Rhododendron* shrubs with *Picea*, on *Juniperus* (base), 1.VII.1994, W.O. 03631 (GZU).

Allocetraria globulans (Nyl.) A. Thell & Randlane

in Daniels *et al.* (eds), Flechten Follmann: 360, 1995. – *Platysma globulans* Nyl., Flora 70: 134, 1887. – Type: China, Yunnan, 1885, *R. P. Delavay 1570* (H-NYL 36 135! – holotype). – *Cetraria globulans* (Nyl.) Zahlbr., Trudy Troitskos.-Kyakhtinsk. Otd. Priamursk. Otd. Imp. Russk. Geogr. Obshch. 12: 89, 1911. – *Nephromopsis globulans* (Nyl.) M. J. Lai, Quart. J. Taiwan Mus. 33: 222, 1981.

Description – see Thell *et al.* (1995).

Typical characters. Thallus dorsiventral, upper surface yellow to brown, lower surface brown. Lobes rather narrow, 2–8 mm wide. Apothecia marginal to submarginal; ascospores globose to subglobose. Pycnidia marginal, on emergent projections; pycnoconidia filiform.

Chemical constituents. Contains usnic acid in the cortex; lichesterinic, protolichesterinic, caperatic (±) acids in the medulla; secalonic acids A and C (±) may also occasionally occur.

Notes. Most of the epiphytic cetrarioid lichens containing usnic acid have rather large dorsiventral thalli; this taxon is one of the smallest, with narrow lobes, and is usually fertile. The shape of both ascospores and pycnospores should be checked, if the identification is doubtful.

Distribution and habitat. Endemic to the Himalayas: has been found in Nepal (Thell *et al.* 1995) and in China (Sichuan, Xizang and Yunnan provinces) (Fig. 2). Grows on twigs of *Potentilla fruticosa* (Thell *et al.* 1995), *Abies*, *Juniperus* and *Rhododendron*, occasionally also on soil at altitudes of 3200–4900 m.

Specimens examined from Tibet and/or neighbouring areas. **CHINA. PROV. SICHUAN.** Between Kangding (Dardo) and Litang, 30°03'N 101°49'E, 3800–3900 m alt., *Rhododendron-Salix-Juniperus*-shrub, on *Rhododendron*, 23.VI.1994, W.O. 03049 (GZU). – ibid., on *Salix*, 23.VI.1994, W.O. 03080 (GZU). – E of Litang, 30°07'N 100°30'E, 4200–4400 m alt., alpine meadows with *Kobresia pygmaea*, on *Rhododendron*, 24.VI.1994, W.O. 03165b (GZU). – Second pass between Kangding (Dardo) and Litang, 30°04'N 101°24'E, 4200–4300 m alt., *Rhododendron* shrub (2–4 m stem height) and alpine meadows, on *Rhododendron*, 23.VI.1994, W.O. 03132 (GZU). – Second pass between Kangding (Dardo) and Litang, 30°04'N 101°24'E, 4200–4300 m alt., *Rhododendron* shrub (2–4 m stem height) and alpine meadows, on *Salix*, 23.VI.1994, W.O. 03136 (GZU). – **PROV. XIZANG**. 120 km SSW of Quamdo (=Changtu), 10 km S of Bamda, 30°09'N 97°17'E, 4500–4600 m alt., *Rhododendron* shrubs, on soil and *Rhododendron*, 5.VII.1994, W.O. 03870b (GZU). – 120 km SSW of Quamdo (=Changtu), 10 km S of Bamda, 30°09'N 97°17'E, 4600–4800 m alt., alpine meadows with Kobresia, on *Rhododendron*, 5.VII.1994, W.O. 03907 (GZU). – Way from Quamdo (=Changtu) to Nagqu (=Nakchu), 31°05'N 96°56'E, 4800 m alt., pass-area, on *Juniperus*, 8.VII.1994, W.O. 04048 (GZU). – Himalaya Range, 280 km ESE of Lhasa, 40 km SW of Mainling, 29°03'N 93°56'E, 3900–4100 m alt., *Juniperus-Abies* forest, on *Rhododendron*, 13.VIII.1994, W.O. 06145 (GZU). – Himalaya Range, 280 km ESE of Lhase, 45 km SW of Mainling, way down from a mountain pasture hut to the valley of a tributary of the Tsangpo, 29°02–03'N 93°54–56'E, 3400–3800 m alt., *Abies* forest, on *Abies*, 14.VIII.1994, W.O. 06232 (GZU).

Allocetraria isidiigera Kurok. & M. J. Lai

Bull. Natl. Sci. Mus. (Tokyo) B, 17: 62, 1991. – Type: China, Xizang, Nyalam, 28°09'N 85°58'E, on *Rhododendron* stem, alt. 3910 m, *J. C. Wei & J. B. Chen 1857* (HMAS – holotype, TNS – isotype!).

Description. Thallus foliose, dorsiventral, slightly attached to the substrate, yellow on the upper surface. Lobes dichtomously branched, elongate, rather narrow, 1–3 mm wide, with scattered cylindrical isidia. Lower surface brown to black, distinctly rugulose, with sparse rhizinae of 0.3 mm long. Marginal pseudocyphellae reported in the original description (Kurokawa & Lai 1991) were not detected in the isotype material. Upper cortex palisade plectenchymatous, *ca.* 10 µm, algal layer 10–15 µm, medulla 100–150 µm, lower cortex 5–9 µm. Medulla white to pale yellow to yellow-ochre. Apothecia rare, laminal, *ca.* 4 mm in diameter; ascospores not seen. Pycnidia numerous, both immersed and elevated on black projections, also at the top of isidia-like structures; pycnoconidia filiform, 11–13 x 0.8 µm.

Typical characters. Tallus dorsiventral, yellow on the upper and brown to black on the lower surface. Lobes elongate, rather narrow (up to 3 mm), isidiate. Contains fumarprotocetraric acid in the medulla, Pd + red.

Chemical constituents. Contains usnic acid in the cortex; fumarprotocetraric, protcetraric and secalonic acid together with related pigments in the medulla; an unknown fatty acid has also been detected using TLC (fumarprotocetraric acid, protcetraric acid and fatty acid were not reported by the authors of the taxon who used microcrystallization methods only).

Notes. This species is poorly known. The present description was compiled from the original Latin description and observations made on the isotype specimen. The original authors of this taxon (Kurokawa & Lai 1991) state that *A. isidiigera* is closer to *A. stracheyi* than to *A. ambigua*, while the main characteristic for separating *A. isidiigera* is the presence of sparse isidia. We do not consider the presence of sparse isidia-like structures a reliable character and suggest that this taxon is very closely related to *A. flavonigrescens* – see the description of the latter species for their distinguishing characters. Another poorly known Chinese taxon is ***A. denticulata*** **(Hue) A. Thell & Randlane** which has been recorded only once (Hue 1899) – from the type locality in Yunnan province (Fig. 2). This species is also distinguished by a rather brief description (Thell *et al.* 1995) and might be closely allied (if not conspecific) to these taxa. The status of *A. denticulata* cannot be reliably determined until the type material is available for study.

Distribution and habitat. Known only from the type locality in Xizang province, China (Fig. 2).

Allocetraria madreporiformis **(Ach.) Kärnefelt & A. Thell**

Nova Hedwigia 62: 508, 1996. – *Dufourea madreporiformis* Ach., Lich. Univ.: 525, 1810. – Type: Helvetia [Switzerland], *Acharius* (H-ACH 1507! – lectotype, selected here). – *Dactylina madreporiformis* (Ach.) Tuck., Proc. Amer. Acad. Arts Sci. 5: 398, 1862. – *Cetraria madreporiformis* (Ach.) Müll. Arg., Flora 53: 325, 1870. – *Dufourea madreporiformis* var. *irregularis* Vain., Bot. Tidsskr. 26: 241, 1904. – Type: [Kirghisia] Western Tjanschan, Talas Alatau, Tjuss Aschu, alt. 13 500 feet, 1898–99, *B. Fedtschenko*, Herb. Vainio No. 01151 (TUR!). – *Dactylina madreporiformis* f. *irregularis* (Vain.) Lynge, Skr. Svalbard Ishavet (Oslo) 59: 39, 1933.

Description – see Kärnefelt & Thell (1996).

Typical characters. Thallus yellow to brown, radially symmetric, slightly inflated, becoming arachnoid in the center. Medulla white. Pycnidia immersed or slightly emergent.

Chemical constituents. Contains usnic acid in the cortex and a lichesterinic-protolichesterinic type fatty acid in the medulla.

Notes. In the typical form this taxon is easily recognized by the radially symmetric thallus and white medulla. The variety *Dactylina madreporiformis* var. *irregularis* (Vain.) Lynge has been referred to as having a distinctly dorsiventral thallus (Thomson & Bird 1978). However, the original description of this taxon (... *vulgo leviter compressis aut plus minusve irregulariter subcylindricis* ...) (Vainio 1904) as well as the type material demonstrate that this is not correct – the thallus of var. *irregularis* is inflated, obviously radially symmetric and occasionally slightly compressed. Therefore the collections with distinctly flat lobes from Colorado in North America reported by Weber & Shushan (1955) and Imshaug (1957) are, in our opinion, *A. stracheyi* rather than *A. madreporiformis*.

Distribution and habitat. This is the most widely distributed *Allocetraria* species which occurs in the arctic and alpine areas of North America and Asia, and in the mountains of central Europe (Fig. 3). In Asia it is known from China (Qinghai, Xinjiang, Xizang and Yunnan provinces), Kirghizia, Mongolia, and Russia (Wei, 1991; Kärnefelt & Thell 1996). Grows on soil, preferably calcareous soils.

Specimens examined from Tibet and/or neighbouring areas. **CHINA. PROV. QINGHAI.** On the SE slope of Mt. Kan She Ka, Leng Long Ling, 37°36'N 102°15'E, Nan Shan, Kun Lun Shan, NE of the Haibei Research Station (nos 27–36), 4000–4500 m alt., upper alpine belt. 19.-20.VII.1985, V.K. 27;31;233-1;235-1 (GZU).

***Allocetraria oakesiana* (Tuck.) Randlane & A. Thell**
in Daniels *et al.* (eds), Flechten Follmann: 363, 1995. – *Cetraria oakesiana* Tuck., Boston J. Nat. Hist. 3: 445, 1841. – Type: White Mountains, alpine regions, on small branches of dwarf firs, 25.06.1839, *Oakes* (FH! – lectotype). – *Platysma oakesianum* (Tuck.) Nyl., Mém. Soc. Sci. Nat. Cherbourg 3: 172, 1855. – *Tuckermannopsis oakesiana* (Tuck.) Hale, Bryologist 90: 164, 1987. – *Cetraria oakesiana* var. *spinulosa* G. Merr., Bryologist 13: 25, 1910. – *Cetraria bavarica* Kremp., Flora 34: 273, 1851. – Type: Germany, Oberbayern, 06.1851, *Krempelhuber* (UPS! – isolectotype).

Description – see Thell *et al.* (1995).

Typical characters. Thallus dorsiventral, yellow on the upper surface and brown to dark yellow or light tan on the lower surface. Marginal soredia and medulla white to very pale yellow. Pseudocyphellae absent on both surfaces. Medulla Pd –.

Chemical constituents. Contains usnic acid in the cortex and fatty acids (caperatic, lichesterinic and protolichesterinic acids) in the medulla; secalonic acids also occur (±) in the lower parts of the medulla (Thell et al. 1995).

Notes. The species might be confused with *Tuckneraria laureri*; for differences therefrom – see the description of the latter species.

Another sorediate cetrarioid lichen, *'Cetraria' xizangensis* is morphologically very similar to *A. oakesiana* but differs from it in medullary chemistry and is easily identified by the positive Pd reaction on the medulla.

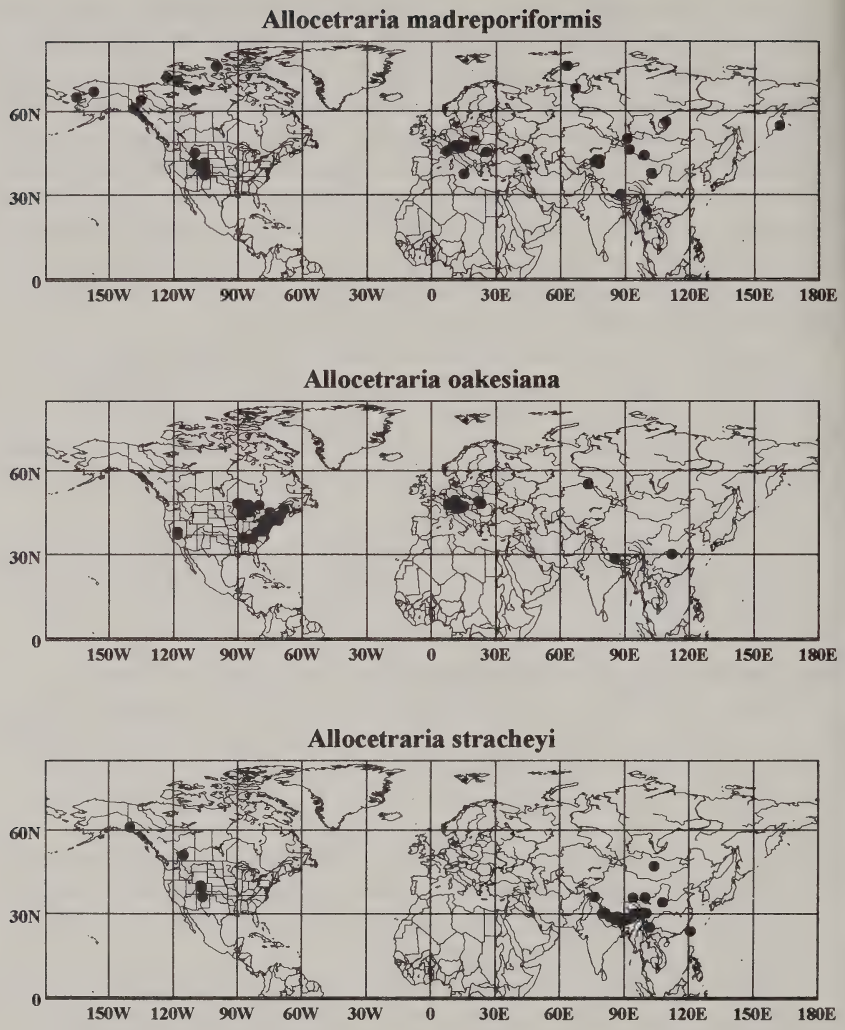
Allocetraria madreporiformis
Allocetraria oakesiana
Allocetraria stracheyi
60N
30N
0
150W
120W
90W
60W
30W
0
30E
60E
90E
120E
150E
180E

Fig. 3. World distribution of *Allocetraria* species (II).

The former species is extremely rare, being known only from the type locality in Nyalam (China, Xizang province) only.

Distribution and habitat. Another widely distributed *Allocetraria* species which grows in the montane forests of Central Europe (Austria, Germany, Italy, Slovakia, Ukraine), in North America (Canada, USA) and Asia (China, Nepal, Russia) (Fig. 3). In China this taxon has only been found occasionally – in central China in Hubei (Wei 1991), and now from Xizang province. This species is corticolous on coniferous and deciduous trees.

Specimens examined from Tibet and/or neighbouring areas. **CHINA. PROV. XIZANG.** Central Himalayas, Upper Trisuli gorge, W of Mt. Xixabangma, 28°33'N 85°18'E, 4440 m alt., *Rhododendron anthopogon* dwarf-scrub, on *Rhododendron*, 22.VIII.1993, G. & S.M. 9544/11-1 (GZU). – **NEPAL.** Central Nepal, Langtang valley, Kyangjin, 28°13'N 85°34'E, 3910–4210 m alt., 06–21.VIII.1995, U.W. 16-1, 25, 31, 58 (GZU).

***Allocetraria sinensis* X. Q. Gao**

in Daniels *et al.* (eds), Flechten Follmann: 365, 1995. – Type: China, Shaanxi, Mt. Taibai, alt. 3400 m, on ground, *X. Q. Gao 3052* (HMAS – holotype, LD!, UPS! – isotypes).

Description – see Thell *et al.* (1995).

Typical characters. Thallus dorsiventral, yellow on the upper surface and brown on the lower surface. Lobes elongate. Marginal pseudocyphellae present on the lower side in the form of a white continuous line. Medulla Pd–.

Chemical constituents. Contains usnic acid (±) in the cortex; lichesterinic, protolichesterinic and an unknown fatty acid in the medulla; secalonic acid A and other related pigments (±) may also occur occasionally.

Notes. The taxon can readily be separated from all the other *Allocetraria* species by elongate lobes with a yellow shiny upper surface and a lower surface which is brown, also shiny and has marginal pseudocyphellae. Morphologically it is somewhat similar to *A. flavonigrescens*, but this species has a dark lower surface which lacks pseudocyphellae and has a positive medullary Pd reaction (containing fumarprotocetraric acid).

Distribution and habitat. A rare species, distributed in Nepal and China, in Shaanxi (Thell *et al.* 1995) and now also in Sichuan, Xizang and Yunnan provinces (Fig. 2). Grows on soil at altitudes of 3400–5100 m, and has also been found on debris at the front of a glacier.

Specimens examined from Tibet and/or neighbouring areas. **CHINA. PROV. SICHUAN.** Wenchaun County, pass SW of Wolong, E of Densheng, 30°53'N 102°54'E, 4450 m alt., 8.X.1994, A.B. (GZU). – **PROV. XIZANG.** 360 km E of Lhasa, near the bend of the river Tsangpo, N-side of Gyala Peri, 10 km S of Tongjug village, W-side of the glacier, steep E-facing slopes and ridge area, 29°54'N 94°51–52'E, 4500–4700 m alt., steep E-facing slopes and ridge area, on soil, 19.VIII.1994, W.O. 06518 (GZU). – Himalaya Range, 280 km ESE of Lhasa, 40 km SW of Mainling, way from a mountain pasture hut to the glacier, 29°03'N 93°56'E, 5000–5100 m alt., area on immediate front of a glacier, on soil, 11.VIII.1994, W.O. 05981, 05987 (GZU). – **PROV. YUNNAN.** Reg. bor., 4000–4300 m alt., 21.VII.1922, H. Smith (COLO). – **NEPAL.** Langtang area, above Yala, alt. 4830 m, G. & S.M., 05.VII.1986 (GZU).

Allocetraria stracheyi (Bab.) Kurok. & M. J. Lai
Bull. Natl. Sci. Mus. (Tokyo) Ser. B, 17: 62–63, 1991. – *Evernia stracheyi* Bab., Hooker's J. Bot. Kew Gard. Misc. 4: 244, 1852. – Type: [India] Kumaon, Gori river, among mosses and dead leaves, alt. 4700 ft (?), *R. Strachey & J. E. Winterbottom* (H-NYL 36 055! – lectotype, BM! – isolectotype). – *Platysma everniellum* Nyl., Mém. Soc. Sci. Nat. Cherbourg 5: 100, 1858 (based on *Evernia stracheyi* Bab.). – *Cetraria everniella* (Nyl.) Kremp., Verh. Zool.-Bot. Ges. Wien 18: 315, 1868. – *Cetraria potaninii* Oxner, Zhurn. Bio-Bot. Tsyklu Vseukraïns'k. Akad. Nauk 7–8: 169, 1933. – Type: China, Tibet, Mts Kamenses, inter stat-s Tasso et Penczamu, Tassaschanj, 31.05.1893, *Potanin* (KW! – holotype). – *Allocetraria potaninii* (Oxner) Randlane & Saag, Mycotaxon 44: 492, 1992.

Description – see Thell *et al.* (1995).

Typical characters. Thallus dorsiventral, yellow on the upper surface and yellow to pale brown on the lower surface; occasionally almost radially symmetric. Lobes elongate, rather narrow (up to 4 mm) and distinctly convex on the upper side. Medulla white or pale yellow to orange.

Chemical constituents. Contains usnic acid in the cortex; lichesterinic and protolichesterinic fatty acids in the medulla; secalonic acids (A or C) together with other pigments (endocrocin) may occur occasionally also in the medulla. A recently described lichen substance, hybocarpone (Ernst-Russell *et al.* 1999), known only from *Lecanora hybocarpa* and *Allocetraria endochrysea* has also been detected. Three other pigments, eumitrin T, eumitrin W, and secalonic acid Z2, have been identified by Elix & Wardlaw (in sched.) in several specimens of *Allocetraria stracheyi.* These pigments belong to the group of secalonic acid (ergochrome) and eumitrin derivatives of which several related but structurally unidentified substances have recently been detected (Elix & Tønsberg 1999). The presence of the cited pigments is responsible for the colour of the medulla which may vary from white to yellow or orange in different specimens.

Notes. The taxon is morphologically rather variable – the thallus may be either dorsiventral or sometimes more or less radially symmetric. In the latter case it is easily recognized as most other *Allocetraria* species do not have radially symmetric thalli. The thalli of *A. endochrysea* and *A. madreporiformis* are also subterete but these are rather different – cylindrical, slightly inflated, becoming arachnoid in the center, and only sparsely branched. When the thallus of *A. stracheyi* is distinctly dorsiventral, it may be confused with *A. ambigua*. In such cases it is useful to consider the cross section of lobes. The dorsiventral lobes of *A. stracheyi* are more or less convex on the upper side whereas the lobes of *A. ambigua* are clearly concave. In a few cases (three from more than 80 specimens examined by us) sorediate thalli have been observed.

Distribution and habitat. This taxon has generally been considered a typical Himalayan species, occurring in China, India and Nepal (Kurokawa & Lai 1991). In China it has been found in Shaanxi, Taiwan, Xizang, Yunnan (Wei 1991) and now also in Qinghai, Sichuan and Xinjiang provinces. Some years ago *Allocetraria potaninii* was synonymized with *A. stracheyi* (Thell *et al*. 1995) and its distribution proved much wider than expected – extending to the eastern territories of Mongolia (Golubkova 1981). We now report it also for Colorado, western North America, (see discussion under *A. madreporiformis*) (Fig. 3). Even so, *A. stracheyi* is not the most widely distributed species in the genus since both *A. madreporiformis* and the sorediate *Allocetraria oakesiana* are known from Europe, Asia and North America (Thell *et al*. 1995; Kärnefelt & Thell 1996). In Asia *A. stracheyi* usually grows on soil in alpine meadows at the altitudes of 4200–5800 m. Occasionally it is epiphytic on *Rhododendron*. In North America it has been found on soil among mosses at somewhat lower altitudes (3800–4500 m).

Selected specimens examined from Tibet and/or neighbouring areas. **CHINA. PROV. QINGHAI.** Kunlun Shan, Northern declivity, E of Kunlun Shankou, SW of Golmud, 35°41'N 94°14'E, 4610 m alt., upper slope with *Kobresia pygmaea* turfs colonized by Dicots, on ground, 1.VIII.1993, G. & S.M. 9378/16-1 (GZU). – **PROV. SICHUAN.** Shalui Shan Mts., 40 km NNE of Batang, 30°14'N 99°34'E, 4700–4850 m alt., alpine meadows with *Kobresia* and *Rhododendron* shrubs, on soil, 28.VI.1994, W.O. 03519-2 (GZU). – E of Litang, 30°07'N 100°30'E, 4200–4400 m alt., alpine meadows with *Kobresia pygmaea*, on soil, 24.VI.1994, W.O. 03145(GZU). – **PROV. XINJIANG.** Karakorum, 35°58'N 76°28'E, 5000 m alt., alpine meadows with *Carex*, *Kobresia*, on ground, 23.IX.1986, B.D. F22-1, F22-2 (GZU). – **PROV. XIZANG.** West Himalaya, Upper Karnali, Burang, 30°08'N 81°20'E, 4640 m alt., 25–26° N-exp. surface of rock glacier with snow-beds, on ground, 31.VIII.1993, G. & S.M. 9620/19-1 (GZU). – Himalaya Range, 190 km SSE of Lhasa, 28°07'N 91°55'E, 4650–4800 m alt., alpine meadows, on ground and *Rhododendron*, 30.VII.1994, W.O. 05061a (GZU). – Mountain directly SW above Nyalam, 28°09'N 85°58'E, 4000–4770 m alt., lower to upper alpine belt, on soil, 5.-6.VII.1986, V.K. 362-1, 362-2 etc. (GZU). – Nyainqêntanglha Shan, 340 km E of Lhasa, pass between Nyingchi and Dongjug, 29°37'N 94°39'E, 4500 m alt., alpine meadows with boulders, on ground, 16.VIII.1994, W.O. 06330 (GZU). – **NEPAL.** Kali-Gandaki-Gebiet, NW of Tukuche, (28°43'N 83°40'E), 4200 m alt., alpine meadow with *Rhododendron*, 12.IV.1979, U.K. 3–5 (GZU). – NNW Manangbhot, E Muktinath, 5300 m alt., on rocks, 28.IX.1979, U.K. (GZU). – East-Nepal, Khumbu, Ngozumpa glacier, Cho Oyu base camp, 5380 m alt., on soil, 2.X.1982, G.M. (GZU). – Langtang Area, way from Kyangjin to Nubama Dhang, 3750–3900 m alt., rocks; riveraine scrub; pasture, on ground, 11.IX.1986, J.P. N86-L140-2 (GZU).

American specimens examined. **USA. COLORADO.** Clear Creek Co., Mt. Evans, tundra above Lincoln Lake, 3830 m alt., 25. VIII.1954, W.A. Weber L-3761 (COLO, TU). – Rocky shore of Summit Lake, NE slope of Mt. Evans, 4230 m alt., 22.VII.1955, W.A. Weber L-5619. – Rocky Mt. Front Range, 4500 m alt., moss tundra, on soil, 15.VII.1998, W.A. Weber, J. Corbridge & R. Wittmann L-93,142 (COLO, TU). – Grand Co., head of Current Creek, Berthoud Pass, 3800–4170 m alt., 6.VII.1960, W.A. Weber L-24776a (COLO, TU). – Larimer Co., Rocky Mt. Nat. Park, Trail Ridge Road, 4000 m alt., tundra, VII.1957, Shushan & Thomson L-9054 (COLO, TU). – Park Co., Summit Co., east end of Hoosier Ridge, 11 miles N of Fairplay, 4330 m alt., 8.VII.1956, Shushan & Imshaug L-8218 (COLO, TU).

***'Cetraria' leucostigma* Lév.**

in Jacquemont, Voyage dans l'Inde Bot.: 180, 1841–1844.– Type: India orientalis, dédit *J. H. Léveillé* (H-NYL 36 083! – neotype, proposed by Awasthi 1983). – *Platysma leucostigmeum* (Lév.) Nyl., Mém. Soc. Sci. Nat. Cherbourg 5: 100. 1858. – *Cetraria sikkimensis* Räsänen, Arch. Soc. Zool. Bot. Fenn. Vanamo 5: 25, 1950. – Type: [India] Sikkim, Chhangu, alt. *ca.* 3900 m, on branches of *Rhododendron* shrub, 05.1947, *D. D. Awasthi 355* (H – holotype, Herb. Awasthi – isotype).

Description. Thallus dorsiventral, suberect to erect, 3–5(8) cm high, irregularly branched; lobes plane or involute, of medium size, 5–7(10) mm broad, with undulate margins; upper surface yellow to pale brown, lower surface shiny, brown with occasional yellowish patches. Pseudocyphellae laminal, round or oval, *ca.* 0.3 mm in diameter, white, plain or concave, present on the lower surface only; rhizines, isidia and soredia absent. Medulla white. Apothecia rare, marginal, round to oblong, 16 x 6 mm; ascospores ellipsoid, 8–9 x 6 µm (according to Awasthi 1983; ascomata not seen in present work). Pycnidia black, on emergent marginal projections; pycnoconidia not seen.

Typical characters. Thallus dorsiventral, yellow on the upper surface and brown on the lower surface. Lobes rather wide (up to 7 mm). Pseudocyphellae distinct on the lower side – laminal, round or oval, white.

Chemical constituents. Contains usnic acid in the cortex; lichesterinic and protolichesterinic acids in the medulla.

Notes. For differences from *'C'. melaloma* see under that species.

Distribution and habitat. A rare lichen, known only from Bhutan, India and Nepal (Awasthi 1983, 1988) (Fig. 4). Not recorded from Tibet but most probably occurs there. Grows on soil or on twigs of shrubs (*Rhododendron*) in alpine areas at altitudes of 3500–4500 m.

Specimens examined. **BHUTAN. THIMPHU DISTR.** Between Sim Kotaa lakes and Gigme Latsho, 27°32'N 89°31'E, 3900–4100 m alt., alpine meadow with *Rhododendron*, on soil, 4.V.1998, U. Søchting 9151 (TU). – **INDIA.** India orientalis, ad *Quercum truncos* (location unknown), dédit J. H. Léveillé (H-NYL 36 083 – neotype). – **NEPAL.** Langtang area, Chisedang Lekh, N-exposed very humid slopes S above Palpa (Papal) towards Palphu, 3500–4000 m alt., 7.IX.1986, J.P. 86-L605 (GZU). – Ganja La (N), 4160 m alt., *Rhododendron anthopogon* scrub, N-exp., on ground, 17.VII.1986, G. & S.M. 5715 (GZU). – Keldang, Dupku Danda, 4490 m alt., N-facing *Potentilla coriandrifolia* assoc., 27.VII.1986, G. & S.M. 6771a (GZU). – Pangsang Lekh, 4000 m alt., N-facing slope with *Rhododendron anthopogon*, on mosses, 29.V.1986, G. & S.M. 2520 (GZU). – East Nepal, Topkegola, ridge between Rupapokhari and Sajupokhari, 4500 m alt., on ground and twigs of a small *Rhododendron*, 30.V.1953, D.D. Awasthi 2409 (COLO) – Lamjung Himal, Rambrong, in moss anf grass among boulders, 10.VII.1954, Staiton, Sykes & Williams 6255 (BM).

***'Cetraria' melaloma* (Nyl.) Kremp.**

Verh. Zool.-Bot. Ges. Wien 18: 315, 1868. – *Platysma melalomum* Nyl., Syn. Lich. 1: 303, 1860. – Type: [India] Sikkim, Jongri, regione alpina, supra

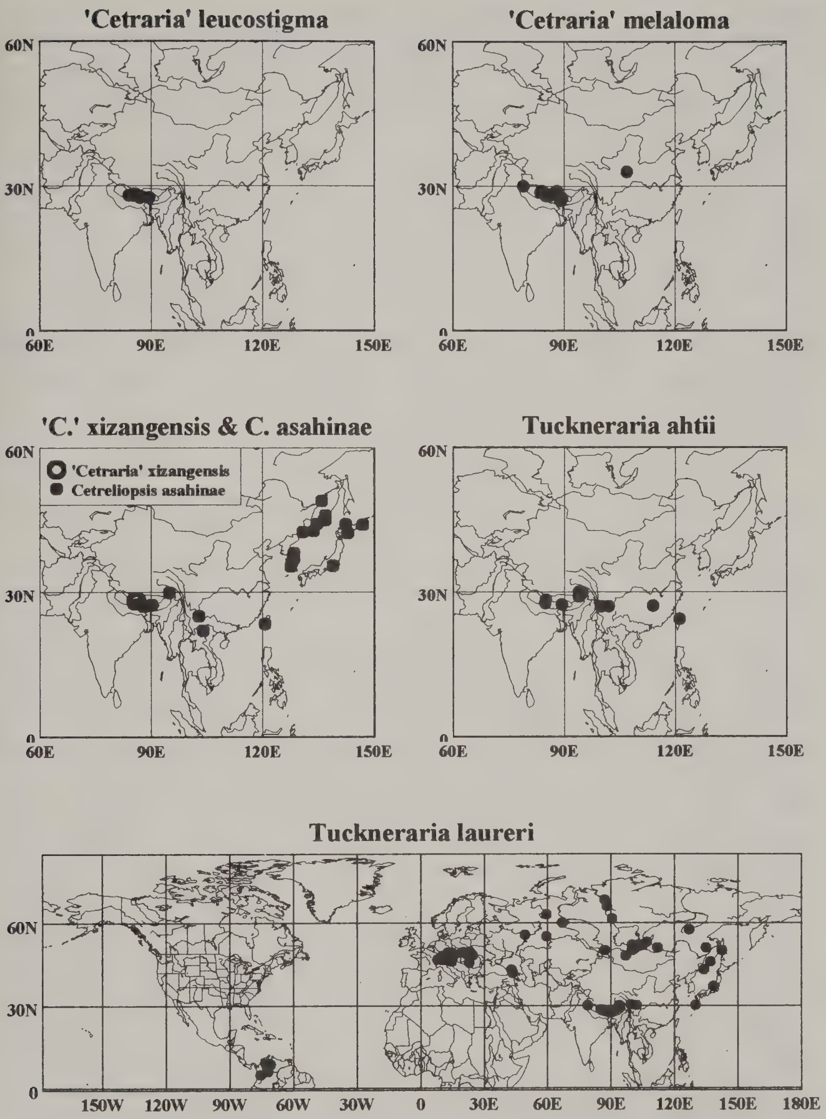
'Cetraria' leucostigma
'Cetraria' melaloma
60N
30N
0
60E
90E
120E
150E
'C.' xizangensis & C. asahinae
○ 'Cetraria' xizangensis
● Cetreliopsis asahinae
Tuckneraria ahtii
Tuckneraria laureri
150W
120W
90W
60W
30W
0
30E
60E
90E
120E
150E
180E

Fig. 4. World distribution of some *Cetraria*, *Cetreliopsis* and *Tuckneraria* species.

mare alt. 13 000 ft, inter Cladonias et muscos, *J. D. Hooker 2665* (BM! – lectotype, H-NYL 36 072! – isolectotype). – *Cetraria pallida* D. D. Awasthi, Proc. Indian Acad. Sci. 45: 130, 1957. – Type: Nepal, Topkegola, Thaglabhanjyang, alt. 4200 m, 29.05.1953, *D. D. Awasthi 2347* (Herb. Awasthi – holotype).

Description. Thallus dorsiventral, suberect to erect, 2–3.5 cm high, irregularly branched; lobes plane or involute, of medium size, 2–6 mm broad, with undulate margins; both surfaces pale yellow up to brownish yellow, often with brown margins and always with black marginal projections; pseudocyphellae laminal, round or oval, *ca.* 0.5 mm in diameter, grey in colour, surrounded by a black or brown rim, may be present on both surfaces but more usual on the lower surface only; rhizines, isidia and soredia absent. Medulla white. Apothecia unknown. Pycnidia black, on short marginal projections; pycnoconidia not seen.

Typical characters. Thallus dorsiventral, pale yellow to brownish yellow on both surfaces. Lobes rather wide (up to 6 mm). Pseudocyphellae – laminal, round or oval, grey, surrounded by a dark rim – may be present on both surfaces but are more common on the lower surface.

Chemical constituents. Contains usnic acid in the cortex; lichesterinic and protolichesterinic acids in the medulla. According to Awasthi (1983), stictic acid has also been detected occasionally.

Notes. The species is morphologically rather similar to another rare Asian *Cetraria* – '*C.*' *leucostigma* Lév. However, the latter is darker in colour (usually yellow on the upper and brown on the lower surface), with white pseudocyphellae only on the lower surface. Apothecia have not been observed in '*C.*' *melaloma*, and have only been reported once in '*C.*' *leucostigma* (Awasthi 1983) but have not been thoroughly studied. Pycnidia have been observed in both species but pycnoconidia have not been detected in either taxon. We agree with Thell (1996) that '*C.*' *leucostigma* and '*C.*' *melaloma* do not belong to the genus *Cetraria* s. strict. According to the revised definition of the genus (Kärnefelt *et al.* 1993), all the cetrarioid lichens containing usnic acid have been excluded from *Cetraria* s. strict. Presence of one-layered palisade plectenchymatous cortex with anticlinally arranged hyphae in '*C.*' *leucostigma* and '*C.*' *melaloma* (Thell 1996) is not characteristic of *Cetraria* s. strict. either. The systematic position (generic location) of these two species has yet to be determined (Randlane *et al.* 1997), and will be dependent upon a detailed investigation of ascomata or upon molecular analysis.

Distribution and habitat. A rare species, known from India (Awasthi 1983, 1988), Nepal (Awasthi 1983) and China – Shaanxi and Xizang provinces (Wei 1991); and now also from Bhutan (Fig. 4). Grows on soil among mosses or on rocks in alpine meadows at altitudes of 3500–4800 m.

Specimens examined. **BHUTAN. Thimphu distr.** Between Gigme Lang tsho and Jaley la Dzong, 27°30'N 89°30'E, 3980 m alt., alpine meadow, on soil, 05.V.1998, U. Søchting 9181 (TU). **INDIA. Sikkim.** Jongri, alpine reg., alt. 13 000 ft, between Cladonias and mosses, J.D. Hooker 2665 (BM – lectotype, H-NYL 36 072 – isolectotype). – **Uttar Pradesh.** Almora distr., Phurkia to near Pindari glacier, near Mirtoli, alt. 3450 m, on ground under *Rhododendron* bushes, 11.VI.1970, D. Awasthi 7695 (COLO). – **NEPAL.** Kali-Gandaki area, NW Tukuche, between Tukuche [28°43'N 83°40'E] and Dhampuspass, S-exposed slope with *Rhododendron* in alpine meadow, 4200 m alt., 12.IV.1979, U.K s.n. 6 (GZU). – Langtang area, Central Himalaya, Upper Langtang, near Kyangjing, 3900 m alt., on boulders, 25.VI.1986, G. & S.M. 4016b (GZU). – Ganja La, 4140 m alt., *Rhododendron* dwarf scrub, NW-exp., on ground, 17.VII.1986, G. & S.M. 5675 (GZU). – Langshisa Glacier, E lateral moraine, 4610 m alt., *Rhododendron–Potentilla fruticosa* scrub, W-exp., on ground, 16.IX.1986, G. & S.M. 12059 (GZU). – Pemdang Karpo, terminal moraine, 4660 m alt., *Potentilla fruticosa–Cyperaceae* pasture, ESE-exp., 7.X.1986, G. & S.M. 13590 (GZU). – ibid., *Rhododendron* dwarf-scrub, NW-facing slope, on ground, 7.X.1986, G. & S.M. 13602e (GZU). – Rocks, riverain scrub, pasture on way from Kyangjin to Nubama Dhang, 3750–3900 m alt., 11.IX.1986, J.P. N86-L140-1 (GZU). – Schiabru N-flank, 4440 m alt., *Rhododendron anthopogon* dwarf scrub on N-facing slope, on ground, 24.X.1986, G. & S.M. 14752f (GZU). – Slopes N above Nubama Dhang, 4300–4500 m alt., pasture, moraines, rocks, 13.IX.1986, J.P. N86-L737 (GZU).

'Cetraria' xizangensis J. C. Wei & Y. M. Jiang

Acta Phytotax. Sin. 18: 288, 1980. – Type: [China] Xizang, Nyalam, silvicola, ad corticem *Betula*, alt. 3900 m, 22.06.1966, *J. C. Wei & J. B. Chen 1899* (HMAS – holotype, isotype!).

Description. Thallus foliose, dorsiventral, suborbicular to irregular, *ca.* 1–3 cm in diameter, yellow. Lobes rounded, partly crenulate and undulate and sparsely pruinose in lobe apices, with marginal white to pale yellow granular soredia; the sorediate zone 0.5–2 mm wide. Lower surface yellow to brown, with brown rhizinae. Thallus *ca.* (95) 139–177 (196) µm thick; upper cortex *ca.* 21–27 µm, algal layer *ca.* 21–50 µm, medulla *ca.* 21–98 µm, lower cortex *ca.* 17–21 µm. Algal photobiont green, cells *ca.* 11–17 µm in diameter. Medullary hyphae 3–4 µm; medulla white. Pycnidia and apothecia unknown.

Typical characters. Thallus dorsiventral, yellow on the upper surface and yellow to brown on the lower surface, with marginal white granular soredia. Medulla white, Pd + orange.

Chemical constituents. Contains usnic acid in the cortex; fumarprotocetraric (major), protocetraric (minor), lichesterinic and protolichesterinic acids in the medulla.

Notes. The species is not well known. The present characterization is compiled from the original Latin description (Wei & Jiang 1980) and the study of isotype material. The taxon is said to be similar to *Vulpicida pinastri* but the medulla and soredia are white and the medullary colour tests with K and Pd are positive (Wei & Jiang 1980). In our opinion *'C.' xizangensis* is morphologically very similar to *Allocetraria oakesiana* but the chemistry of the two taxa is quite different. The Pd reaction on the medulla should be used to distinguish these lichens (positive in *'C.' xizangensis* and negative in *A.*

oakesiana). The true generic position of '*C.*' *xizangensis* has yet to be determined as no ascospores nor pycnidiospores have been detected. Still, it is evident that this taxon does not belong to *Cetraria* s. strict.

Distributiona and habitat. Known only from the type locality in Xizang province, China (Fig. 4). Grows on trees (*Betula*) at rather high altitude (3900 m).

***Cetreliopsis asahinae* (M. Satô) Randlane & A. Thell**

Cryptog. Bryol. Lichénol. 16: 46, 1995. – *Cetraria asahinae* M. Satô, Res. Bull. Saito Ho-On Kai Mus. 11: 12, 1936. – Type: [Russia] Kuril Islands, Kunashiri, Tomarimura, 16.08.1923, *Yasuda* (DUKE – isotype).

Description – see Randlane *et al.* 1995.

Typical characters. Thallus dorsiventral, upper surface yellow, lower surface black. Lobes rather wide (8–15 mm). Pseudocyphellae on the upper surface surrounded with a black rim and bearing black emergent projections; on the lower surface they appear as small white spots. Medulla Pd + red.

Chemical constituents. Contains usnic acid in the cortex (rarely absent); protocetraric (major compound), fumarprotocetraric and physodalic (±) acids in the medulla.

Notes. The taxon is readily distinguished by the apparent pseudocyphellae on the upper surface, an unusual feature for this group. The pseudocyphellae on the lower side are less conspicuous. The medullary chemistry – that is the presence of protocetraric and fumarprotocetraric acids – and the occurence of pseudocyphellae on both surfaces is typical for this genus.

Distribution and habitat. Distributed in Bhutan; in China – in Taiwan, Xizang (Wei 1991) and Yunnan provinces; in India and Nepal (*Cetraria rhytidocarpa sensu* Awasthi in Awasthi 1983), Japan (Yoshimura 1979), Russian Far East – in Habarovsk and Primorye regions and the Kuril Islands (Randlane *et al.* 1995, Skirina 1998); in South Korea (Park 1990) and Vietnam (Randlane *et al.* 1995) (Fig. 4). Grows in mixed and deciduous forests, epiphytic on living and fallen trees (e.g. *Abies*, *Picea*, *Quercus*, *Rhododendron*, *Tilia*) at lower and medium altitudes (up to 3500 m).

Specimens examined from Tibet and/or neighbouring areas. **BHUTAN. WANGDI DISTR.** Phobji valley, Khebeythang, 27°30'N 90°11'E, 2620 m alt., mixed forest, 14.IV.1998, U. Søchting 8060 (TU). – **CHINA. PROV. XIZANG.** Nyainqêntanglha Shan, 360 km E of Lhasa, near the bend of the river Tsangpo, N-side of Gyala Peri, 29°54–55'N 94°52–53'E, 3500 m alt., *Rhododendron-Abies* forest, on *Rhododendron*, 18.VIII.1994, W.O. 06646 (GZU). – **PROV. YUNNAN.** Schilungba prope Yünnan-fu, 1950 m alt., 19.II.1914, H. Handel-Mazzetti 45 (WU).

***Flavocetraria cucullata* (Bellardi) Kärnefelt & A. Thell**

Acta Bot. Fenn. 150: 81, 1994. – *Lichen cucullatus* Bellardi, Osservaz. Bot.: 54, 1788. – Type: TO. – *Platysma cucullatum* (Bellardi) Hoffm., Descr. Adumbr. Plant. Lich. 3: 17, 1801. – *Cetraria cucullata* (Bellardi) Ach., Meth. Lich.: 293, 1803. – *Parmelia cucullata* Spreng., Syst. Veget. 4(1): 281, 1827.

– *Allocetraria cucullata* (Bellardi) Randlane & Saag, Mycotaxon 44: 492, 1992.

Description – see Kärnefelt *et al.* 1994.

Typical characters. Thallus erect, dorsiventral, yellow on both surfaces with reddish basal parts. Lobes strongly canaliculate or subtubular.

Chemical constituents. Contains usnic acid in the cortex; lichesterinic and protolichesterinic acids in the medulla. Several anthraquinone pigments are present in the basal parts of the thallus, in both the cortex and medulla.

Notes. Two well-known yellow species – *F. cucullata* and *F. nivalis* – were recently transferred from *Cetraria* to a newly described genus *Flavocetraria* on the grounds of anatomical characters (shape of pycnoconidia, structure of upper cortex) and cortical chemistry (Kärnefelt *et al.* 1994). *F. cucullata* is usually easily recognized by its typical canaliculate or subtubular lobes.

Distribution and habitat. Widely distributed in arctic and boreal regions of the northern hemisphere; also occurs in cold temperate areas of southernmost South America (Kärnefelt *et al.* 1994). In Asia it is known from China [Neimongol, Xizang and Yunnan provinces (Wei 1991)], India (Awasthi 1983), Japan (Yoshimura 1979; Kurokawa 1991), Mongolia (Golubkova 1981), Nepal (Kurokawa 1993) and Russia (Rassadina 1950). We have not examined any herbarium specimens of *A. cucullata* from Tibet but its occurrence there has been recorded in literature (Wei 1991). Grows on ground among mosses and other lichens in tundra or alpine vegetation.

Flavocetraria nivalis (L.) Kärnefelt & A. Thell
Acta Bot. Fenn. 150: 84, 1994. – *Lichen nivalis* L., Spec. Plant.: 1149, 1753. – Type: LINN 1273.101 (lectotype). – *Cetraria nivalis* (L.) Ach., Meth. Lich.: 293, 1803. – *Platysma nivale* (L.) Frege, Deutsch. Bot. Tachenbuch 2: 161, 1812. – *Parmelia nivalis* (L.) Spreng., Syst. Veget. 3: 525, 1831. – *Allocetraria nivalis* (L.) Randlane & Saag, Mycotaxon 44: 492, 1992.

Description – see Kärnefelt *et al.* 1994.

Typical characters. Thallus erect, dorsiventral, yellow on both surfaces with basal parts dark yellow. Lobes foveolate and strongly wrinkled, especially on the upper side.

Chemical constituents. Contains usnic acid in the cortex. No medullary compounds detected.

Notes. *F. nivalis* is a well-known lichen normally readily distinguished by its yellow thallus and strongly wrinkled lobes. In the Himalayas it may be confused with *Allocetraria ambigua*. For differences from the latter see under *Allocetraria ambigua*.

Distribution and habitat. Widely distributed in arctic and boreal regions of the northern hemisphere; occurs also in cold temperate areas of southernmost South America (Kärnefelt *et al.* 1994). In Asia this species is more restricted than *C. cucullata*, recorded from China [Neimongol, Xinjiang and Xizang provinces (Wei 1991)], Japan (Yoshimura 1979; Kurokawa 1991), Mongolia (Golubkova 1981) and Russia (Rassadina 1950). A related but separate taxon, *F. nivalis* ssp. *montana* Kärnefelt & A. Thell, is known from New Guinea (Kärnefelt *et al.* 1994). This species is included in the present study on the basis of the literature (Wei 1991). Grows on ground among mosses and other lichens in tundra or alpine vegetation.

Nephromopsis komarovii **(Elenkin) J. C. Wei**

Enumer. Lich. China: 158, 1991. – *Cetraria komarovii* Elenkin, Izv. Imp. S.-Peterburgsk. Bot. Sada 3: 51, 1903. – Type: Russia, Irkutsk region, in viciniis Nilova Pustyn, ad terram montis Chongoldoi montium Sajanensium, 1902, *A. Elenkin 155* (LE – holotype, FH!, W! – isotypes). – *Cetraria perstraminea* Zahlbr., Trudy Troitskos.-Kyakhtinsk. Otd. Priamursk. Otd. Imp. Russk. Geogr. Obshch. 12: 88, 1911. – Type: Russia, Transbaicalia, Chilgindin, 10.10.1908, *P. S. Mikhno* (W! – holotype).

Description – see Randlane & Saag (1998).

Typical characters. Thallus foliose, characteristically rugose (in a somewhat concentric pattern), intense green to lemon yellow on the upper surface and brown on lower surface. Marginal but juvenile apothecia often present.

Chemical constituents. Contains usnic acid in the cortex; lichesterinic and protolichesterinic acids in the medulla; fumarprotocetraric acid (Huneck *et al.* 1984), stictic and constictic acids (personal communication from T. Ahti) have also been detected in some specimens.

Distribution and habitat. Distributed in China [Hebei, Jilin (Wei 1991), Shaanxi and Sichuan provinces], Mongolia and Russia (see Fig. 2 in Randlane & Saag 1998). Not recorded from Tibet but highly probable there. The only epilithic representative in this group of yellow cetrarioid lichens. Grows over the rocks and boulders in shaded localities in montane forests at lower and medium altitudes (up to 3000 m).

Specimens examined from Tibet and/or neighbouring areas. **CHINA. PROV. SICHUAN.** Distr. monasteri Muli, ad rupes in pinetis prope vic. Hosö, ca 2950 m alt., 8.VIII.1915, H. Handel-Mazzetti 1364 (WU).

Nephromopsis laii **(A. Thell & Randlane) Saag & A. Thell**

Bryologist 100: 111, 1997. – *Cetrariopsis laii* A. Thell & Randlane, Cryptog. Bryol. Lichénol. 16: 46, 1995. – Type: Russia, Primorye region, Kedrovaya Padj Nature Reserve, 17.09.1961, *S. Pärn* (TU! – holotype, LD! – isotype).

Description – see Randlane *et al.* (1995).

Typical characters. Thallus dorsiventral, moderately rugose, upper surface greenish yellow, lower surface pale brown to brown. Lobes rather wide (8–15 mm), often with secondary marginal lobules. Pseudocyphellae small and flat, mainly developed on the ridges of the lower side. Apothecia marginal, numerous, often juvenile only.

Chemical constituents. Contains usnic acid in the cortex; alectoronic and/or lichesterinic, protolichesterinic-type fatty acids in the medulla.

Notes. This species can be confused with *Nephromopsis pallescens* var. *pallescens* or *N. nephromoides*. *N. pallescens* is usually readily distinguished by numerous, small, laminal apothecia with clearly rounded discs while the apothecia of *N. laii* are mainly marginal or submarginal and the disc is often reniform. Nevertheless, the apothecia of *N. laii* can be quite similar to those of *N. nephromoides* and then the lower side of the thallus should be examined. Pseudocyphellae are small and flat and situated mainly on the brown coloured ridges of the generally paler lower surface in *N. laii*, while the pseudocyphellae of *N. nephromoides* are medium to large, flat or concave and developed directly on the surface. Secondary lobules forming a fringe along the margins of lobes are characteristic for *N. laii*.

Distribution and habitat. Distributed in China, India, Japan, Russia, Vietnam (see Fig. 3 in Randlane & Saag 1998). In China it has been found in Taiwan, Yunnan, now also in Xizang provinces. Corticolous on coniferous (*Abies*, *Pinus*) and deciduous (*Betula*, *Sorbus*, *Quercus*) trees in mountain forests at the altitude 600–3300 m.

Specimens examined from Tibet and/or neighbouring areas. **CHINA**. **PROV. XIZANG.** Himalaya Range, 275 km ESE of Lhasa, 60 km SW of Mainling, 29°02'N 93°53–54'E, 3150–3250 m alt., forest area close to a river, on *Sorbus*, 9.VIII.1994, W.O. 05817(GZU).

Nephromopsis morrisonicola M. J. Lai

Quart. J. Taiwan Mus. 33: 223, 1981. – Type: [China], Taiwan, Nanton Co., Mt. Morrison, alt. 3500–3900 m, 1978, *M. J. Lai 10 438* (TAIM! – holotype).

Description see Randlane *et al.* (1995).

Typical characters. Thallus dorsiventral, upper surface yellow, lower surface black (only the margins may be brown to pale brown). Lobes rather wide (8–15 mm). Medulla white. Pseudocyphellae on the lower surface only.

Chemical constituents. Contains usnic acid (±) in the cortex; lichesterinic, protolichesterinic and caperatic (±) acids in the medulla.

Notes. The most conspicuous characters for separating *N. morrisonicola* from other *Nephromopsis* species is black underside **and** white medulla. *N. ornata*, another taxon with black lower surface, has pale yellow medulla. Some *Cetreliopsis* species which may also appear similar to *N. morrisonicola* (e.g. *C. asahinae*) are readily separated by the presence of pseudocyphellae also on the upper surface and the positive Pd reaction of the medulla.

Distribution and habitat. Distributed in China, Indonesia, Nepal, Papua New Guinea and the Philippines (see Fig. 4 in Randlane & Saag 1998). In China it has been found in Taiwan, Yunnan, now also in Xizang provinces.

Corticolous on coniferous (*Abies*) and deciduous (*Betula*) trees or shrubs (*Vaccinium*) in mountainous forests at rather high altitude (2400–4000 m).

Specimens examined from Tibet and/or neighbouring areas. **CHINA**. **Prov. Xizang.** 360 km E of Lhasa, near the bend of the river Tsangpo, N-side of Gyala Peri, 10 km S of Tongjug village, 29°54'N 94°52'E, 3800–3900 m alt., steep E-facing slopes and ridge area, on *Abies*, 19.VIII.1994, W.O. 06778, 06779, 06785 (GZU).

***Nephromopsis nephromoides* (Nyl.) Ahti & Randlane**

Cryptog. Bryol. Lichénol. 19: 183, 1998. – *Platysma nephromoides* Nyl., Flora 52: 442, 443, 1869. – Type: India, West Bengal, Darjeeling distr., Tongloo, alt. 10 000 ft., *Hooker fil. & T. Thomson 2080* (H-NYL 36 068! – lectotype, B!, PC!, UPS! – isolectotypes). – *Nephromopsis stracheyi* var. *nephromoides* (Nyl.) Räsänen, Kuopion Luonnon Ystäväin Yhdistyksen Julkaisuja, B, 2, 6: 48, 1952. – *Cetraria nephromoides* (Nyl.) D. D. Awasthi, Bull. Bot. Surv. India 24: 11, 1982. – *Nephromopsis stracheyi* f. *ectocarpisma* Hue, Nouv. Arch. Mus. Hist. Nat., Sér. 4, 1: 218, 1899. – Types: Japan, insula Yeso [Hokkaido], in sylvis Mombetsu, 1891, *U. J. Faurie 3521* (PC! – lectotype); Japan, Onikobe prope Sendai, 1897, *U. J. Faurie 284* (BM! – paratype). – *Nephromopsis ectocarpisma* (Hue) Gyeln., Ann. Cryptog. Exot. 4: 173, 1931.

Description see Randlane & Saag. (1998).

Typical characters. Thallus dorsiventral, smooth or slightly wrinkled, upper surface greenish yellow, lower surface pale brown. Lobes rather wide (8–15 mm). Pseudocyphellae medium to large, flat or concave, developed directly on the lower surface. Apothecia marginal, numerous, rather small (up to 8 mm in diameter).

Chemical constituents. Contains usnic acid in the cortex; lichesterinic, protolichesterinic and additionally some other fatty acids, e.g. caperatic acid (±) in the medulla.

Notes. This species may be confused with *Nephromopsis laii*. For distinguishing characters see discussion under that species. *N. nephromoides* has previously been treated as an infraspecific taxon of *N. stracheyi*. Although the general habit of the thallus and the character of pseudocyphellae on the lower surface of these two species are rather similar, the differences are still distinct – the apothecia of *N. stracheyi* are usually much larger (up to 20 mm in diameter), and the medulla is C + red.

Distribution and habitat. Distributed in Bhutan, China, India, Japan, Nepal and Vietnam (see Fig. 5 in Randlane & Saag 1998). In China it has been found in Hebei, Heilongjiang, Shaanxi, Sichuan, Taiwan, Xizang and Yunnan provinces (Wei 1991). Corticolous on living and fallen trees at the altitude 2400–3600 m.

Specimens examined from Tibet and/or neighbouring areas. **BHUTAN. Paro distr.** Drugey Dzong. 27°30'N 89°20'E, 2600 m alt., pine forest, on *Pinus wallichiana*, 21.IV.1998, U. Søchting 8214 (TU). – **Thimphu distr.** Dochu la pass, SW of Thimphu, 27°30'N 89°45'E, 3150 m alt., mixed *Tsuga-Rhododendron* forest, 30.IV.1998, U. Søchting 8465 (TU).

***Nephromopsis ornata* (Müll. Arg.) Hue**

Nouv. Arch. Mus. Hist. Nat., Sér. 4, 2: 90, 1900. – *Cetraria ornata* Müll. Arg., Nuovo Giorn. Bot. Ital. 23: 122, 1891. – Type: Japan, Mt. Ontake, No. 109. – *Nephromopsis delavayi* Hue, Nouv. Arch. Mus. Hist. Nat., Sér. 4, 1: 219, 1899. – Type: China, Yunnan. Lopinchan, Lanhong, alt. 3200 m, 31.07.1888, *R. P. Delavay* (DUKE). – *Cetraria delavayi* (Hue) M. Satô in Nakai & Honda, Nov. Fl. Jap. 5: 48, 1939. – *Nephromopsis endoxantha* Hue, Nouv. Arch. Mus. Hist. Nat., Sér. 4, 1: 220, 1899. – Type: Japan, Togakushi, 17.09.1898, *U. J. Faurie 776* (KY – lectotype, DUKE – isolectotype). – *Tuckermannopsis endoxantha* (Hue) Gyeln., Acta Fauna Fl. Universali, Ser. 2, Bot. 1, 5/6: 6, 1933. – *Cetraria endoxantha* (Hue) D. D. Awasthi, Bull. Bot. Surv. India 24: 9, 1983.

Description – see Randlane & Saag (1998).

Typical characters. Thallus dorsiventral, upper surface greenish yellow, lower surface brown to almost black. Lobes rather wide (8–15 mm). Medulla pale yellow, K + deep yellow.

Chemical constituents. Contains usnic acid in the cortex; secalonic acids A or C in the medulla, occasionally several fatty acids and traces of endocrocin and fumarprotocetraric acid are also present.

Notes. A beautiful and easily recognized lichen characterized by the brown or black underside **and** yellow medulla. If fertile, the nephromoid apothecia often very large (to 20 mm in diameter) and attractive.

Distribution and habitat. Distributed in China, Japan, Russia and South Korea (see Fig. 6 in Randlane & Saag 1998). In China it has been found in Jilin, Sichuan, Taiwan, and Yunnan provinces (Wei 1991); probably also occurs in Tibet although not yet recorded. Corticolous on coniferous and deciduous trees in forests at lower and medium altitudes (up to 3200 m).

Nephromopsis pallescens* (Shaer.) Y. S. Park var. *pallescens

Bryologist 93: 122, 1990. – *Cetraria pallescens* Schaer., in Moritzi, Syst. Verzeichn.: 129, 1845–1846. Type: [Indonesia] Java, Mt. Pangerango, *H. Zollinger 449* (G! – holotype). – *Platysma pallescens* (Schaer.) Nyl., Mém. Soc. Sci. Nat. Cherbourg 5: 100, 1858. – *Cetrariopsis pallescens* (Schaer.) Randlane & A. Thell, Cryptog. Bryol. Lichénol. 16: 42, 1995. – *Sticta wallichiana* Taylor, London J. Bot. 6: 177, 1847. – Type: Nepal, *N. Wallich* (FH – holotype, G 2003/1!, G 2003/2!, PC! – isotypes). – *Parmelia wallichiana* (Taylor) Nyl., Mém. Soc. Sci. Nat. Cherbourg 5: 105, 1858. – *Platysma leucostigmeum* var. *wallichianum* (Taylor) Nyl., Syn. Meth. Lich. I: 306, 1860. – *Platysma wallichianum* (Taylor) Nyl., Flora 52: 443, 1869. – *Cetraria wallichiana* (Taylor) Müll. Arg., Flora 71: 139, 1888. – *Cetrariopsis wallichiana* (Taylor) Kurok., Mem. Natl. Sci. Mus. Tokyo 13: 140, 1980. – *Ahtia wallichiana* (Taylor) M. J. Lai, Quart. J. Taiwan Mus. 33: 220, 1981 (*nom. illeg.*). – *Cetraria sulphurea* Mont. & Bosch, in Montagne, Syll. Gen.

Sp. Crypt.: 322, 1856 (not validly published). – Orig. coll.: [Indonesia] Java, *F. W. Junghuhn*. – *Cetraria teijsmannii* ("*Teysmanni*") Mont. & Bosch, in Montagne, Syll. Gen. Sp. Crypt.: 474, 1856. – Type: [Indonesia] Java, *J. E. Teijsmann*. – *Platysma teijsmannii* ("*Teysmanni*") (Mont. & Bosch) Nyl., Mém. Soc. Sci. Nat. Cherbourg 5: 100, 1858.

Description – see Randlane *et al.* (1995).

Typical characters. Thallus dorsiventral, upper surface greenish yellow, lower surface white to yellow. Lobes rather wide (8–15 mm). Pseudocyphellae on the lower surface on special plug-like outgrowths. Apothecia small and numerous, mainly laminal.

Chemical constituents. Contains usnic acid in the cortex; alectoronic and/or lichesterinic, protolichesterinic acids in the medulla.

Notes. The species which is well-known and easily recognized in its typical form by the laminal apothecia which is unusual for cetrarioid lichens. Even so, some specimens have ascoma developed mainly along the margins of the upper surface with only a few laminal apothecia. In such specimens the lower surface should be checked for the presence of pseudocyphellae on special outgrowths – especially in the central part of the thallus.

Distribution and habitat. Distributed in China, India, Indonesia, Japan, Nepal, Papua New Guinea, Russia, South Korea and Thailand (see Fig. 7 in Randlane & Saag 1998). In China it has been found in Sichuan, Taiwan, Xizang and Yunnan provinces (Wei 1991). Corticolous on coniferous (*Larix*, *Pinus*) and deciduous (*Carpinus*, *Populus*, *Salix*, *Sorbus*, *Quercus*) trees or shrubs (*Berberis*, *Rhododendron*, *Spirea*) in mountainous forests at medium and high altitudes (1200–4300 m).

Selected specimens examined from Tibet and/or neighbouring areas. **CHINA**. **PROV. SICHUAN.** Shalui Shan Mts., 35 km NNE of Batang, 30°16'N 99°28'E, 4200–4300 m alt., pasture with schist outcrops and single *Juniperus* trees, on *Spirea*, 27.VI.1994, W.O. 03443 (GZU). – **PROV. XIZANG.** Himalaya Range, 275 km ESE of Lhasa, 60 km SW of Mainling, 29°02'N 93°53–54'E, 3150–3250 m alt., forest area close to a river, on *Sorbus*, 9.VIII.1994, W.O. 05811, 05812, 05818, 05821, 05823, 05842 (GZU). – Nyainqêntanglha Shan, 360 km E of Lhasa, near the bend of the river Tsangpo, 5 km S of Tongjug village, 29°58'N 94°54'E, 2700 m alt., on *Berberis*, 18.VIII.1994, W.O. 06608 (GZU). – Ibid., on *Populus*, 21.VIII.1994, W.O. 06890 (GZU). – 370 km E of Lhasa, near the bend of the river Tsangpo, between the villages Tongjug and Tangmai, 30°01'N 94°58'E, 2300–2400 m alt., deciduous trees along the river, on dead *Populus*, 23.VIII.1994, W.O. 07065 (GZU).

***Nephromopsis stracheyi* (Bab.) Müll. Arg.**

Flora 74: 374, 1891. – *Cetraria stracheyi* Bab., Hooker's J. Bot. Kew Gard. Misc. 4: 245, 1852. – [India], Himalaya, Kathi, 7200 ft, *R. Stracheyi & E. Winterbottom* (BM – holotype, H-NYL 36 138! – isotype). – *Platysma stracheyi* (Bab.) Nyl., Flora 52: 443, 1869.

Description – see Randlane & Saag (1998).

Typical characters. Thallus dorsiventral, often very large (to 20 cm in diameter), upper surface yellowish grey, lower surface brown. Lobes wide (up to 30 mm). Pseudocyphellae medium to large, flat or concave, forming directly on the lower surface. Medulla white, C + red. Apothecia marginal, often very large (to 20 mm in diameter).

Chemical constituents. Contains usnic acid in the cortex; olivetoric or anziaic acid in the medulla.

Notes. For differences from *N. nephromoides* see under that species.

Distribution and habitat. Distributed in Bhutan, China, India, Nepal (see Fig. 9 in Randlane & Saag 1998). In China it has been found in Hubei, Taiwan and Yunnan provinces (Wei 1991); probably also occurs in Tibet although not yet recorded. Grows on trees at low and medium altitudes (up to *ca.* 3000 m).

Specimens examined from Tibet and/or neighbouring areas. **BHUTAN. WANGDI DISTR.** Phobji valley, Khebeythang, 27°23'N 90°11'E, 2620 m alt., mixed coniferous forest, on *Rhododendron*, 15.IV.1998, U. Søchting 8095, 8105 (TU). **NEPAL.** Yamphoshin, 27°27'N 81°57'E, 9000 ft. alt., on tree trunk, 25.VI.1969, L. Williams 954 (BM).

***Nephromopsis yunnanensis* (Nyl.) Randlane & Saag**

Mycotaxon 44: 488, 1992. – *Platysma yunnanense* ("*yunnense*") Nyl., Lich. Nov. Zeland.: 150, 1888. – Type: China, Yunnan, alt. 1800 m, *R. P. Delavay 1602* (H-NYL 36 134! – lectotype). – *Cetraria yunnanensis* (Nyl.) Zahlbr., Trudy Troitskos.-Kyakhtinsk. Otd. Priamursk. Otd. Imp. Russk. Geogr. Obshch. 12: 89, 1911.

Description – see Randlane *et al.* (1995).

Typical characters. Thallus dorsiventral, upper surface yellow, lower surface white to pale brown and extremely rugose. Lobes rather wide (8–15 mm). Pseudocyphellae on the lower surface on ridges and plug-like outgrowths. Pycnidia numerous, both laminal and marginal, on pale emergent projections.

Chemical constituents. Contains usnic acid in the cortex; lichesterinic and protolichesterinic acids in the medulla.

Notes. A rare lichen, endemic to southern China. *N. yunnanensis* is not easily confused with any other species and can be recognized by the numerous pycnidia on pale emergent projections which develop both marginally and laminally on the upper and sometimes even on the lower surface.

Distribution and habitat. Distributed in China: prewiously known from Yunnan province (see Fig. 10 in Randlane & Saag 1998) and now also from Xizang. Corticolous on coniferous (*Picea*) and deciduous (*Quercus*, *Sorbus*) trees in mountain forests at the altitude 1800–3200 m.

Specimens examined from Tibet and/or neighbouring areas. **CHINA. PROV. XIZANG.** Himalaya Range, 275 km ESE of Lhasa, 60 km SW of Mainling, 29°02'N 93°53–54'E, 3150–3250 m alt., forest area close to a river, on *Sorbus*. – 9.VIII.1994, W.O. 05828, 05829, 05842 (GZU).

Tuckneraria ahtii Randlane & Saag

Acta Bot. Fenn. 150: 147, 1994. – Type: China, Prov. Yunnan, Lijiang County, Mt. Yulongshan, lower central E slope, Ganheba, 3200–3300 m, 27°06'N 100°14'E, on *Abies*, 23.04.1987, *T. Ahti, J. B. Chen & L. S. Wang 46 649* (H! – holotype, TU! – isotype).

Description – see Randlane *et al.* (1994).

Typical characters. Thallus dorsiventral, upper surface yellowish grey, lower surface pale to dark brown. Lobes rather narrow (4–10 mm wide). Marginal cilia may be present. Pycnoconidia bifusiform (5 x 1–1,5 µm). Ascospores subglobose (5–7 x 4–5 µm).

Chemical constituents. Contains usnic acid (±) in the cortex; lichesterinic, protolichesterinic, caperatic (±) and occasionally other unidentified fatty acids in the medulla.

Notes. A taxon which is not easily distinguished by morphology alone, but by the shape of both ascospores and pycnospores.

Distribution and habitat. Distributed in Bhutan, China – in Sichuan, Taiwan, Xizang and Yunnan provinces – and Nepal (Randlane *et al.* 1994) (Fig. 4). Corticolous on coniferous (*Abies*, *Juniperus*, *Picea*) and deciduous (*Hippophae*, *Salix*) trees or shrubs (*Rhododendron*) in mountain forests at the altitude 3200–4500 m.

Selected specimens examined from Tibet and/or neighbouring areas. **BHUTAN. PARO DISTR.** Chele la pass, 27°22'N 89°29'E, 3900 m alt., subalpine zone, on and among dwarf *Rhododendron*, 1.V.1998, U. Søchting 8489 (TU). **CHINA. PROV. XIZANG.** Nyainqêntanglha Shan, 350 km E of Lhasa, 20 km E of Nyingchi, 29°36'N 94°44'E, 3800 m alt., *Picea-Abies* forest, on *Abies*, 27.VIII.1994, W.O. 07140 (GZU). – 275 km E of Lhasa, 70 km E of Gongbo Gyamda, 30°00'N 93°56–57'E, 3500–3600 m alt., mixed forest, on *Hippophae*, 29.VIII.1994, W.O. 07138 (GZU). – 350 km E of Lhasa, 29°36'N 94°44'E, 3650–3750 m alt., flood plain area along a small rivulett, on *Abies*, *Picea*, *Salix*, 24.–25.VIII.1994, W.O. 07142, 07143, 07144, 07146 (GZU). – 360 km E of Lhasa, near the bend of the river Tsangpo, 29°56–58'N 94°53–54'E, 3000 m alt., on *Abies*, 21.VIII.1994, W.O. 06936 (GZU). – Himalaya Range, 280 km ESE of Lhasa, 45 km SW of Mainling, 29°02–03'N 93°54–56'E, 4000–4100 m alt., *Abies* forest, on *Abies*, 10.VIII.1994, W.O. 05915 (GZU). – **PROV. YUNNAN.** Mt. Yulong-shan near Lijiang, 3450–3500 m alt., H. Handel-Mazzetti 3563 (FH, US). – Lijiang Co., Yangtze watershed, eastern slopes of Lijiang Snow Range, Rock 11 773 (UPS). – **NEPAL.** Langtang area, Pamdang Karpo, 4620 m alt., 1986, G. & S.M. 13 056f (GZU). – Langtang area, terminal moraine of Langtang Glacier, 4480 m alt., 1986, G. & S.M. 12 424.

Tuckneraria laureri (Kremp.) Randlane & A. Thell

Acta Bot. Fenn. 150: 149, 1994. – *Cetraria laureri* Kremp., Flora 34: 673, 1851. – *Nephromopsis laureri* (Kremp.) Kurok., J. Jap. Bot. 66: 156, 1991. – *Cetraria complicata* Laurer, in Fries, Lichenogr. Eur. Ref. 459, 1831 (*nom. nud.*). – *Platysma complicatum* (Laurer) Nyl., Syn. Lich. 1: 303. 1860 (*nom. inval.*). – *Cetraria straminea* Kremp. ex Schwend. in Nägeli, Beitr. Wiss. Bot. (Leipzig) 2: 154, 1860.

Description – see Randlane *et al.* (1994).

Typical characters. Thallus dorsiventral, pale yellow on the upper surface and white to pale brown on the lower surfce, with marginal whitish soredia and scattered cilia. Lower surface with small pseudocyphellae. Medulla white, Pd –.

Chemical constituents. Contains usnic acid in the cortex; lichesterinic and protolichesterinic acids in the medulla.

Notes. A taxon which had earlier been confused with another sorediate cetrarioid lichen *Allocetraria oakesiana*. These two species are morphologically somewhat similar as both have rather small yellow dorsiventral thalli and the marginal soralia. However, these taxa are distinct both anatomically (filiform pycnoconidia in *A. oakesiana*, bifusiform pycnoconidia in *T. laureri*) and chemically (occurence of caperatic acid and occasionally also secalonic acid in *A. oakesiana*). The careful investigation of the lower surface reveals small pseudocyphellae in *T. laureri* but never in *A. oakesiana*. *A. oakesiana* is widely distributed in North America and Europe but occurs just occasionally in Asia (China, Nepal, Russia).

Distribution and habitat. A very extensively distributed taxon in different parts of the world: in montane forests of many countries in Central Europe – Austria, Germany, Italy, Poland, Romania, Slovakia, Switzerland, Ukraine; in Asia – Bhutan, China, India, Japan, Mongolia, Nepal, Russia; in South-America – Colombia, Venezuela (Fig. 4). In China it is known from Sichuan and Xizang provinces. Corticolous on coniferous (*Abies*, *Juniperus*, *Picea*, *Pinus*) and deciduous (*Betula*, *Hippophae*, *Lonicera*, *Quercus*, *Prunus*, *Rhododendron*, *Salix*, *Sorbus*) trees or lignicolous at altitudes 2400–5100 m.

Selected specimens examined from Tibet and/or neighbouring areas. **BHUTAN. Paro distr.** Chele la pass, 27°22'N 89°20'E, 3900 m alt., subalpine zone, on dwarf *Rhododendron*, 1.V.1998, U. Søchting 9066 (TU). – **Thimphu distr.**, Thimphu valley below Tango Gonpa, 27°36'N 89°38'E, 2700 m alt., temperate oak forest with *Rhododendron*, on dead wood, 28.IV.1998, U. Søchting 8403 (TU). – **Wangdi distr.**, Phobji valley, Khebeythang, 27°30'N 90°11'E, 2620 m alt., mixed forest, on rotten Tsuga stump, 15.IV.1998, U. Søchting 8124 (TU). – **CHINA. Prov. Sichuan.** Shalui Shan Mts., 30 km NNE of Batang, SSE of Yidun, 30°16'N 99°25'E, 4100–4150 m alt., S-facing slope with *Quercus*, *Juniperus* and *Picea*, on *Quercus*, 26.VI.1994, W.O. 03341 (GZU). – E of Litang, 30°07'N 100°30'E, 4200–4400 m alt., alpine meadows with *Kobresia pygmaea*, on *Rhododendron*, 24.VI.1994, W.O. 03161, 03165a (GZU). – **Prov. Xizang.** Himalaya Range, 170–175 km S of Lhasa, between Lhozhag and Lhakhang Dzong, 28°18'N 90°57'E, 4250 m alt., *Betula-Rhododendron* forest, on *Betula utilis*, 22.VII.1994, W.O. 04818, 04840, 04859 (GZU). – Himalaya Range, 180 km SE of Lhasa, 100 km SSE of Tsetang (Nedong), 28°35'N 92°28'E, 4200–4300 m alt., canyon with *Betula* - *Rhododendron* forest, on *Rhododendron*, 27.VII.1994, W.O. 04610 (GZU). – Everest E, Kama Chu, W of Sakyetang (Camp Ev3–4), 27°58'N 87°13'E, 4320 m alt., subalpine *Abies-Juniperus-Rhododendron* forest, on *Abies*, *Juniperus*, *Rhododendron*, 24.X.1989, B.D. K-87-1 (GZU). – Central Himalayas, Upper Trisuli gorge, W of Mt. Xixabangma, 28°32'N 85°16'E, 4310 m alt., subalpine thickets, on *Rhododendron*, *Sorbus*, 23.VIII.1993, G. & S.M. 9549/13-1, 9549/13-2 (GZU). – Nyainqêntanglha Shan, 275 km E of Lhasa, 70 km E of Gongbo Gyamda, 30°00'N 93°56–57'E, 3500 m alt., on wood, 30.VIII.1994, W.O. 07156, 07628 (GZU). – **NEPAL.** Central Nepal, Langtang valley, Kyangjin, 28°13'N 85°34'E, 3790–4420 m alt., 02–21.VIII.1995, U.W. 09, 39, 41-1, 46, 47, 56, 57, 60, 64 (GZU).

Vulpicida juniperina (L.) J.-E. Mattsson & M. J. Lai
Mycotaxon 49: 427, 1993. – *Lichen juniperinus* L., Species Plantarum: 1147, 1753. – Type: LINN 132 (lectotype). – *Cetraria juniperina* (L.) Ach., Meth. Lich.: 298, 1803. – *Tuckermannopsis juniperina* (L.) Hale, Bryologist 90: 164, 1987.

Description – see Mattsson (1993).

Typical characters. Thallus dorsiventral, greenish yellow on both surfaces, with bright yellow medulla; soredia absent but apothecia and pycnidia common.

Chemical constituents. Contains usnic acid in the cortex; pinastric and vulpinic acids in the medulla; some other substances – zeorin and other triterpens – have also been detected by TLC (Mattsson 1993) but they have no taxonomic importance.

Notes. The species is distinguished by the bright yellow medulla due to the presence of pinastric and vulpinic acids; the absence of soredia is the diagnostic character which separates this taxon from *Vulpicida pinastri*.

Distribution and habitat. Distributed in boreal and mountainous regions of northern Europe and north-eastern Asia (see Figs 18–20 in Mattsson 1993). In Asia this species is much rarer than *V. pinastri*; known from China (Jilin and Xinjiang provinces) (Wei 1991; Abbas & Wu 1998), Japan (Yoshimura 1979; Kurokawa 1991), Mongolia (Biazrov *et al.* 1989), and Russia (Rassadina 1950). We have not examined any specimens of *V. juniperina* from Tibet, but its occurrence in neighbouring areas (Xinjiang province) has been recorded in literature (Abbas & Wu 1998). It is an epiphyte that is mainly restricted to *Juniperus communis* in Europe and to *Pinus pumila* in Asia. Occasionally grows also on *Betula* or on calcareous soil.

Vulpicida pinastri (Scop.) J.-E. Mattsson & M. J. Lai
Mycotaxon 49: 428, 1993. – *Lichen pinastri* Scop., Flora Carniolica 2: 382, 1772. – Type: Italy, Friuli, Prov. Udine, Carnic Alps, road between Sauris and Casera Razzo, ca 3 km before the latter, subalpine *Larix*-woodland, on *Larix*, 1750 m, 24.03.1993, *P. L. Nimis* (LD! – neotype, TSB – isoneotype). – *Cetraria juniperina* var. *pinastri* Ach., Meth. Lich.: 298, 1803. – *Cetraria pinastri* (Scop.) S. F. Gray, Natural Arrang. Brit. Plants 1: 432, 1821. – *Tuckermannopsis pinastri* (Scop.) Hale, Bryologist 90: 164, 1987.

Description – see Mattsson (1993).

Typical characters. Thallus dorsiventral, greenish yellow on both surfaces, with bright yellow marginal soredia and medulla of the same colour.

Chemical constituents. Contains usnic acid in the cortex; pinastric and vulpinic acids in the medulla; several other substances – zeorin and other triterpens – have also been detected by TLC (Mattsson 1993) but they have no taxonomic importance.

Notes. The species is distinguished by the bright yellow marginal soredia and medulla, caused by the presence of pinastric and vulpinic acids.

Distribution and habitat. Widely distributed in arctic, boreal and mountainous regions of the northern hemisphere (see Figs 23 & 24 in Mattsson 1993). In Asia known from China (Neimongol, Jilin, Heilongjiang and Xizang provinces) (Wei 1991), Japan (Yoshimura 1979; Kurokawa 1991), Kazakhstan, Mongolia (Golubkova 1981) and Russia (Rassadina 1950). We have not seen any herbarium specimens of *V. pinastri* from Tibet but its occurrence there has been recorded in literature (Wei 1991). Grows preferably on coniferous (*Juniperus*, *Larix*, *Picea*, *Pinus*) but also on deciduous trees with poor bark (*Betula*), occasionally on lignum, rocks and soil.

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IDENTIFICATION OF URBAN LICHENS IN THE FIELD: A CASE STUDY FOR BUENOS AIRES CITY (ARGENTINA)

Nora C. Scutari* & Nérida I. Theinhardt**

Centro Nacional Patagónico, CONICET, Boulevard Brown s/n,
Casilla de Correo 128, 9120 Puerto Madryn, Chubut, Argentina - e-mail: scutari@cenpat.edu.ar
** Universidad CAECE, Depto. Cs. Biológicas,
Av. de Mayo 1496, 4° Piso, Buenos Aires, Argentina

Abstract - Epiphytic lichen diversity in Buenos Aires City is documented. A list of 50 species is presented. *Haematomma subinnatum, Ramalina celastrii, Teloschistes chrysophthalmus* and *Xanthoria fallax*, registered during an earlier survey (1984), probably no longer exist in the City. 44 % of the species were found only in squares or parks. *Scoliciosporum chlorococcum* is a new record for South America. *Pyxine petricola,* an unnamed species of *Caloplaca* with blackish apothecia (close to *Caloplaca floridana*), and an unnamed species of *Endocarpon* are new records for the Pampa region. A key to species is provided including species present both in the City and its surroundings. Thus, the present work is also applicable to a much more extensive urban area, "Gran Buenos Aires", providing a baseline for biomonitoring air pollution also in that region. As most species exhibited very low frequency and coverage, the key was especially designed to reduce as far as possible the need of collecting samples for examination in the laboratory. Comments on the most problematic taxa are included.

KEY WORDS: biodiversity conservation, air pollution, key to species

INTRODUCTION

The study of urban lichens exhibits a number of difficulties. Frequently, thalli are less developed, and exhibit several morphological and physiological modifications (Gries, 1996). Air pollution also affects reproductive potential by reducing both the production of apothecia and spore germination, and increasing the formation of vegetative propagules. Other important effects are discoloration or total bleaching of thalli, and development of populations composed by smaller and more compact thalli. In addition, there are other morphological changes, which depends on the species. Likewise, specific diversity and coverage are reduced.

Several difficulties arise when studying urban lichens in Argentina: 1) lichenological studies in the country have flourished only quite recently (Calvelo, 1998), therefore, there are still many taxonomic groups to be revised and extensive geographical regions to be explored (Adler, 1988; Ruiz, 1991; Scutari 1992a; Stenroos et al., 1992; Calvelo, 1994); 2) the knowledge of the lichen flora is particularly scarce for urban areas; 3) the available keys for identification (Ruiz, 1991; Adler, 1992; Scutari, 1992 b; among others) have been designed to work at the laboratory, since they use many characters which cannot be observed directly in the field, 4) there are particular difficulties for identifying lichen species in polluted areas during surveys because most species exhibit morphological changes and very low frequency and coverage.

In 1984-1985, Ranta & Scutari (unpublished results) undertook a survey in Buenos Aires City, where more than 250 tree trunks were investigated. At that time, 31 lichen species were registered. The present study adds the floristic results of a second survey carried out in 1998-1999, as well as the current knowledge of the epiphytic lichen flora in the surroundings. The main objectives of this study were to facilitate as far as possible the identification of species in the field, reducing to the minimum the need of collecting samples for further examination in the laboratory, and to present a list of epiphytic species as baseline for future monitoring of air pollution in the City using the floristic approach. Furthermore, the study area was chosen with the aim of assessing the methodology for biomonitoring studies not only in Buenos Aires City (Scutari et al., unpublished results) but also in the "Gran Buenos Aires" area, in which the City is included. For this reason, some species absent in the City were also included in the key for being present in the surroundings. Thus, the present work is also applicable to an extensive urban area of ca 3,700 km^2 and more than 10 millions inhabitants.

MATERIAL AND METHODS

Using as reference the material from Buenos Aires Province deposited in BAFC and the first author's private herbarium, all species in the list resulting from the first survey (Ranta & Scutari, unpublished results) were carefully analyzed in order to select those distinctive features which could be observed in the field. Firstly, specimens were examined with a Zeiss SR stereomicroscope (up to 50x). Hand sections of thalli and apothecia, mounted in water or lactophenol cotton-blue, were observed with a Zeiss Jena light microscope (up to 1000x). Spot tests were performed with 10% aqueous solution of KOH (**K**), concentrated sodium hypochlorite (**C**) and ca. 3% alcoholic solution of paraphenylenediamine (**P**). An additional test, **KC** (a drop of **K** followed by a drop of **C**), was also carried out. Secondly, the first author elaborated a first version of the key, using as far as possible only those characters allowing identification in the field. Then, small samples of each species were prepared for fieldwork purposes, and carefully observed with hand lens of different magnifications (2x, 10x and 20x) to get familiar with the appearance of each species under fieldwork conditions. This procedure led to a considerable improvement of the key. Next step was to check the key in the field. For that purpose, excursions to Martín García Island and all sites in the City with highest lichen diversity were made. Finally, those species not found previously were added to the key as they appeared during the second survey. In case of doubtful identifications, small samples were collected for examination in the laboratory.

RESULTS

List of species from Buenos Aires City

During two surveys (1984-1985 and 1998-1999), 50 epiphytic lichen species were found in Buenos Aires City (Table 1). They belong to 28 genera, 12 families and 6 orders (Eriksson et. al., 2001), all of them in the Ascomycotina except for *Lepraria* sp. and *Normandina pulchella* which, being always sterile, are considered as "imperfect" lichens of uncertain position in modern classification systems ("inc. sed."). Some few species could not be identified, even with the help of the corresponding specialists, because the material was too scarce. Forty-

TABLE 1. List of epiphytic lichen species from Buenos Aires City in alphabetic order: systematic position, habit and mode of vegetative reproduction. L = leprose; C = crustose; Sq = squamose or squamulose; Fo = foliose; Fr = fruticose or fruticulose; Ph = phyllidiate; I = isidiate; S = sorediate. *: species found only in parks or squares; #: species registered in 1984, most likely already extirpated.

Species (family, order)	Habit	Vegetative propagules
1. *Bacidia heterochroa* (Müll. Arg.) Zahlbr. * (Bacidiaceae, Lecanorales)	C	absent
2. *Buellia* sp. 1 * (Physciaceae, Lecanorales)	L	--
3. *Buellia* sp. 2 * (Physciaceae, Lecanorales)	C	S
4. *Caloplaca erythrantha* (Tuck.) Zahlbr. * (Teloschistaceae, Teloschistales)	C	absent
5. *Caloplaca scabrida* Magnusson (Teloschistaceae, Teloschistales)	C	I
6. *Caloplaca* sp. 1 * (Teloschistaceae, Teloschistales)	C	absent
7. *Caloplaca sp. 2* * (Teloschistaceae, Teloschistales)	C	absent
8. *Candelaria concolor* (Dickson) Stein (Candelariaceae, Lecanorales)	Fo	S
9. *Candelaria fibrosa* (Fr.) Müll. Arg. * (Candelariaceae, Lecanorales)	Fo	absent
10. *Canomaculina pilosa* (Stizenb.) Elix & Hale * (Parmeliaceae, Lecanorales)	Fo	S
11. *Canoparmelia carneopruinata* (Zahlbr.) Elix & Hale (Parmeliaceae, Lecanorales)	Fo	S
12. *Canoparmelia crozalsiana* (B. de Lesd.) Elix & Hale (Parmeliaceae, Lecanorales)	Fo	S
13. *Canoparmelia texana* (Tuck.) Elix & Hale * (Parmeliaceae, Lecanorales)	Fo	S
14. *Chrysothrix candelaris* (L.) Laundon (Chrysothrichaceae, Arthoniales)	L	--
15. *Dimerella pyrophthalma* (Mont.) Vezda * (Gyalectaceae, Gyalectales)	C	absent
16. *Dirinaria applanata* (Fée) Awasthi (Physciaceae, Lecanorales)	Fo	S
17. *Dirinaria picta* (Swartz) Clements & Shear (Physciaceae, Lecanorales)	Fo	S
18. *Endocarpon* sp. (Verrucariaceae, Verrucariales)	S	absent
19. *Haematomma subinnatum* (Malme) Kalb & Staiger * # (Haematommataceae, Lecanorales)	C	absent
20. *Heterodermia albicans* (Pers.) Swinscow & Krog * (Physciaceae, Lecanorales)	S	S
21. *Heterodermia diademata* (Taylor) Awasthi (Physciaceae, Lecanorales)	Fo	absent
22. *Hyperphyscia adglutinata* (Floerke) Mayrhofer & Poelt (Physciaceae, Lecanorales)	Fo	absent

TABLE 1 (cont.).

Species (family, order)	**Habit**	**Vegetative propagules**
23. *Hyperphyscia* cf. *coralloides* (Lynge) Scutari (Physciaceae, Lecanorales)	Fo	I
24. *Hyperphyscia syncolla* (Tuck.) Kalb (Physciaceae, Lecanorales)	Fo	absent
25. *Lecanora argentata* (Ach.) Degel. * (Lecanoraceae, Lecanorales)	C	absent
26. *Lecanora* sp. 1 * (Lecanoraceae, Lecanorales)	C	absent
27. *Lepraria* sp. (inc. sed.)	L	--
28. *Myelochroa lindmanii* (Lynge) Elix & Hale (Parmeliaceae, Lecanorales)	Fo	I
29. *Normandina pulchella* (Borr.) Nyl. (inc. sed.)	S	S
30. *Pertusaria* sp. (Pertusariaceae, Pertusariales)	C	absent
31. *Phaeophyscia chloantha* (Ach.) Moberg (Physciaceae, Lecanorales)	Fo	S
32. *Physcia aipolia* (Humb.) Fürnr. (Physciaceae, Lecanorales)	Fo	absent
33. *Physcia alba* (Fée) Müll. Arg. (Physciaceae, Lecanorales)	Fo	absent
34. *Physcia biziana* (Massal.) Zahlbr. * (Physciaceae, Lecanorales)	Fo	absent
35. *Physcia crispa* Nyl. (Physciaceae, Lecanorales)	Fo	S
36. *Physcia lacinulata* Müll. Arg. * (Physciaceae, Lecanorales)	Fo	Ph
37. *Physcia poncinsii* Hue (Physciaceae, Lecanorales)	Fo	S
38. *Physcia sinuosa* Moberg (Physciaceae, Lecanorales)	Fo	S
39. *Physcia undulata* Moberg (Physciaceae, Lecanorales)	Fo	S
40. *Punctelia constantimontium* Sérusiaux * (Parmeliaceae, Lecanorales)	Fo	Ph
41. *Punctelia microsticta* (Müll. Arg.) Krog * (Parmeliaceae, Lecanorales)	Fo	absent
42. *Pyxine cocoes* (Swartz) Nyl. (Physciaceae, Lecanorales)	Fo	S
43. *Pyxine petricola* Nyl. (Physciaceae, Lecanorales)	Fo	absent
44. *Pyxine subcinerea* Stirton (Physciaceae, Lecanorales)	Fo	S
45. *Ramalina celastrii* (Spreng.) Krog & Swinscow * # (Ramalinaceae, Lecanorales)	Fr	absent
46. *Rimelia reticulata* (Taylor) Hale & Fletcher (Parmeliaceae, Lecanorales)	Fo	S
47. *Rinodina insperata* (Nyl.) Malme * (Physciaceae, Lecanorales)	C	absent
48. *Scoliciosporum chlorococcum* (Graeve ex Stenh.) Vezda (Lecanoraceae, Lecanorales)	L	absent
49. *Teloschistes chrysophthalmus* (L.) Th. Fr. * # (Teloschistaceae, Teloschistales)	Fr	absent
50. *Xanthoria fallax* (Hepp) Arnold * # (Teloschistaceae, Teloschistales)	Fo	S

four percent of the species were found only in parks and squares (indicated with an asterisk) while the remaining species also appeared on tree trunks along streets and avenues. The following species, registered only during the first survey (1984), are also included in the list since their absence could not be confirmed yet: *Ramalina celastrii* and *Xanthoria fallax* (found during a preliminary survey in 1984 on *Eucalyptus* sp. and *Tipuana tipu*, respectively). *Haematomma subinnatum* and *Teloschistes chrysophthalmus* are considered as extirpated as they disappeared from the only sites they had been found on earlier.

Key to species

With few exceptions, the key was elaborated using characters easily observed in the field (naked eye or hand lens up to 20x). In some cases, microscopic features were added as auxiliary characteristics to ensure a correct identification, and only for a few species such characters were used as main or unique reliable distinctive features (items 37b, 42, 44a, 46, 48, 49a, 50, 51a and 52). Species closely related to those present in the study area known to occur in surrounding urban areas were added (between brackets). Most problematic species, indicated with an asterisk, are commented below.

1a Thallus foliose or fruticose 2
1b Thallus leprose, crustose or squamulose 36
2a Thallus foliose 3
2b Thallus fruticose 35
3a Thallus K+...4
3b Thallus K- 5
4a Thallus yellow-orange, K+ red to purple; with apical soralia originating on the lowerside of the lobes .... *Xanthoria fallax*
4b Thallus grayish, K+ yellow 13
5a Thallus grayish, greenish, olivaceous or whitish 6
5b Thallus yellow 12
6a Soralia apical, labriform; lower surface whitish; medulla K- .... *Phaeophyscia chloantha*
6b Soralia different or absent 7
7a Lower surface dark, with rhizines; thallus densely pruinose, whitish, UV+ yellow; medulla K- 8
7b Lower surface hardly visible (thallus closely appressed and

attached), lacking rhizines; thallus epruinose, UV-; medullary reaction with K variable 10

8a Thallus esorediate .... *Pyxine petricola**

8b Thallus sorediate 9

9a Pruina dense and abundant forming large apical patches or, sometimes, covering most part of the upperside; thallus whitish, ± firmly attached; medulla very pale yellow, K-; soralia initially marginal and linear, then extending and covering most part of the upperside; laminal, orbicular and/or reniform soralia also present .... *Pyxine cocoes**

9b Pruina apical, forming small patches or spotted; thallus darker (greenish or grayish), loosely attached; medulla at least partly yellow-ochreous, K-; soralia orbicular to elliptic, along lobe margins .... *Pyxine subcinerea**

10a Thallus with coralloid appearance; lobes very narrow, ≤ 1 mm in width, partly ascending, with marginal isidioid granules .... *Hyperphyscia* cf. *coralloides**

10b Thallus not coralloid; lobes broader, lacking marginal granules 11

11a Thallus with laminal, crateriform soralia; medulla white (K-) or partly orange to red (K+ purple) ..... *Hyperphyscia adglutinata**

11b Thallus esorediate; medulla either white (K-) or partly red (K+ purple) or partly yellow with variable K reaction (K-, K+ purple, or K+ color intensification) .... *Hyperphyscia syncolla* spec. coll.*

12a Thallus sorediate .... *Candelaria concolor*

12b Thallus esorediate .... *Candelaria fibrosa*

13a Lowerside black 14

13b Lowerside whitish 26

14a Lowerside with rhizines 15

14b Lowerside lacking rhizines 25

15a Upperside with pseudocyphellae 16

15b Upperside lacking pseudocyphellae 17

16a Thallus phyllidiate; pseudocyphellae orbicular, elongated to linear; medulla C+ pink to red ..... *Punctelia constantimontium**

16b Thallus lacking phyllidia or any kind of vegetative propagules; pseudocyphellae orbicular to ellipsoid; medulla C- .... *Punctelia microsticta**

17a Thallus lacking vegetative propagules; medulla C- 18

17b Thallus with vegetative propagules; medullary C reaction variable 19

18a Thallus with effigurate maculae; medulla K- .... (*Canomaculina consors*)

18b Thallus with reticulate maculae, at least in the younger parts of the thallus; medulla K+ dark red (delayed reaction) .... (*Rimelia cetrata*)

19a Thallus isidiate; medulla yellowish, K+ and C+ (intensification of color); marginal cilia scarce to absent .... *Myelochroa lindmanii*

19b Thallus sorediate; medulla white, at least in the upper layers, C-, reaction with K different; margins ciliate or eciliate 20

20a Upper surface of the thallus maculate; thallus ciliate 21

20b Upper surface emaculate; thallus eciliate 22

21a Maculae reticulate; soralia linear; medulla K+ dark red (delayed reaction) .... *Rimelia reticulata*

21b Maculae effigurate; soralia orbicular; medulla K- .... *Canomaculina pilosa*

22a Upper surface smooth; soralia laminal, crateriform; medulla K+ yellow .... (*Physcia erumpens*)

22b Upper surface of the thallus with reticulate crests; soralia laminal, punctiform to orbicular, non-crateriform, usually on crests; medullary K reaction variable 23

23a Medulla K- .... *Canoparmelia texana**

23b Medulla K+ yellow 24

24a Thallus closely adnate, lobes narrow, up to 1-3 mm wide .... *Canoparmelia carneopruinata**

24b Thallus adnate to loosely adnate, lobes to 3-6 mm wide .... *Canoparmelia crozalsiana**

25a Thallus radially plicate, whitish- or sky-blue-grayish, of farinose appearance, lobes with broadened, flabelliform apices .... *Dirinaria applanata**

25b Thallus non- to scarcely plicate, grayish-green, upperside non-farinose, lobes ± linear, apices truncate to rounded .... *Dirinaria picta**

26a Thallus sorediate 27

26b Thallus esorediate 32

27a Thallus with soralia and/or phyllidia; soralia marginal, punctiform, undulate to linear, and/ or laminal, punctiform to orbicular; phyllidia marginal and/or laminal .... *Physcia lacinulata*

27b Thallus only with soralia 28

28a Thallus sky blue-grayish, of granular, frosted appearance (upper cortex with epinecral layer responsible for the bluish tinge of the upperside); soralia marginal, usually at lobe axils, hemiorbicular, with the upper cortex revolute, lobe margins undulate .... *Physcia undulata**

28b Thallus greenish-gray, upper surface smooth (upper cortex lacking epinecral layer), soralia variable 29

29a Soralia laminal, crateriform .... *Physcia poncinsii*

29b Soralia marginal, never crateriform 30

30a Medulla K-; soralia linear, short, lobe margins crisped .... *Physcia crispa**

30b Medulla K+; soralia variable 31

31a Soralia linear; medulla K+ reddish to red (delayed reaction) .... *Heterodermia albicans*

31b Soralia hemiorbicular, at lobe axils; medulla K+ yellow; thallus emaculate, epruinose .... *Physcia sinuosa**

32a Medulla K-; lobes linear, discrete, convex, apices broadened with dense, shiny pruina .... *Physcia biziana**

32b Medulla K+ yellow 33

33a Thallus robust, gray-greenish, upper surface rugose; lobes linear, discrete, epruinose; rhizines long, usually projecting beyond the margins and visible from the upperside of the thallus; upper cortex composed by periclinal hyphae of cylindrical cells (prosenchymatous = prosoplectenchymatous) .... *Heterodermia diademata**

33b Thallus smaller and thinner; rhizines short, visible only from the underside of the thallus; upper cortex composed by anticlinal hyphae of ± isodiametric cells (pseudoparenchymatous = paraplectenchymatous) 34

34a Thallus maculate, pruinose (pruina apical, dull, in variable amounts), upper surface sky-blue gray, farinose, with epinecral layer; lobes non-linear, contiguous, convex, apices broadened, divided, flabelliform .... *Physcia aipolia**

34b Thallus emaculate or with inconspicuous, irregularly distributed maculae, epruinose, upper surface greenish-gray, smooth, lacking epinecral layer; lobes linear, discrete, plane, apices truncate .... *Physcia alba**

35a Thallus ciliate, grayish, K-; apothecial discs orange, K+ purple .... *Teloschistes chrysophthalmus*

35b Thallus eciliate, greenish, K-; apothecial discs yellowish to pale greenish, K- .... *Ramalina celastrii*

36a Thallus squamulose 37

36b Thallus leprose or crustose 38

37a Thallus composed of greenish-yellow, semicircular squamules with revolute margins (ear-like), frequently sorediate; always sterile .... *Normandina pulchella*

37b Thallus ochreous, esorediate; with perithecia containing hymenial algae, immersed in prominent verrucae .... *Endocarpon* sp.

38a Thallus with yellow pigments 39

38b Thallus lacking yellow pigments 40

39a Thallus leprose, K- .... *Chrysothrix candelaris*

39b Thallus crustose, uniform, K+ purple; with laminar isidioid, minute granules .... *Caloplaca scabrida*

40a Thallus leprose 41

40b Thallus crustose 43

41a Thallus pistachio green; always sterile .... *Lepraria* sp.

41b Thallus not pistachio green; with black, inconspicuous apothecia (hardly visible in the field) 42

42a Thallus dull green; hypothecia pale, ascospores colorless, filiform, pluricellular, transversely septate .... *Scoliciosporum chlorococcum**

42b Thallus herbage green; with black, inconspicuous apothecia; hypothecia dark brown, ascospores brownish, ellipsoid, polar-2-cellular, of the *Buellia*-type .... *Buellia* sp. 1*

43a Apothecia with thalline margin 44

43b Apothecia lacking thalline margin 51

44a Apothecia immersed in thalline verrucae; ascospores large, colorless, unicellular, few per ascus .... *Pertusaria* sp.

44b Apothecia superficial 45

45a Apothecial discs yellowish to dark brown, K- 46

45b Apothecial discs yellowish to orange-red, K+ purple 49

46a Apothecia conspicuous, thalline margin well developed, persistent; hypothecia pale; ascospores colorless, ellipsoid ...47

46b Apothecia very small, hardly visible with hand lens, thalline margin very thin, disappearing with age; hypothecia brown; ascospores brown, ellipsoid, polar-2-cellular, of the *Orcularia*-type .... *Rinodina insperata**

47a Apothecial discs yellowish .... *Lecanora* sp.

47b Apothecial discs brownish 48

48a Ascospores polar-2-locular .... *Caloplaca* sp. 1*

48b Ascospores unicellular .... *Lecanora argentata**

49a Apothecia > 1.2 mm diam.; ascospores colorless, ellipsoid, polar-2-locular .... *Caloplaca erythrantha**

49b Apothecia smaller 50

50a Apothecia small, to 0.7 mm diam., conspicuous because of the reddish color, usually confluent; ascospores filiform, pluricellular, transversely septate .... *Haematomma subinnatum**

50b Apothecia inconspicuous, minute, < 0.3 mm diam., discrete, discs ochreous-yellow; ascospores colorless, polar-2-locular .... *Caloplaca* sp. 2

51a Apothecia of pale colors (biatorine); ascospores colorless, bacilliform, pluricellular, transversely septate .... *Dimerella pyrophthalma*

51b Apothecia dark brown to blackish (lecideine) 52

52a Thallus green, with numerous, minute, orbicular soralia, coalescent with age; apothecia very small, hardly visible with high magnification (20x); hypothecia brown; ascospores brown, ellipsoid, polar-2-cellular, of the *Bischoffii*-type .... *Buellia* sp. 2*

52b Thallus greenish-gray; apothecia visible with lower magnification; hypothecia pale; ascospores colorless, filiform, pluricellular, transversely septate .... *Bacidia heterochroa**

DISCUSSION

List of species

The list resulting from the second survey in 1999 (50 species) is much richer than the list after the first survey in 1985 (31 species). Since the number of registered vehicles in Buenos Aires City increased 30% in the mentioned period, initially it was thought that this striking increase of diversity could be attributed to the progress in lichen taxonomy as well as to a sensible increase of lichenological experience by the first author. Although the subject will be discussed more extensively in a forthcoming paper, we should like to mention, however, that a reduction of air pollution could actually occur due to technological progresses in both motors and fuel quality (Scutari et al., unpublished results), with the consequent increase of lichen diversity (Seaward, 1997).

Identification of species

As mentioned above, most species exhibited very low frequency and coverage, as well as some morphological modifications, which were species-specific. For these reasons, the key was designed in order to allow, as far as possible, the identification of species in the field. As additional help, comments on the problems for recognizing most problematic taxa are discussed below.

1. Foliose lichens

Among foliose species (64 %), difficulties for identification in the field are found among the Physciaceae and Parmeliaceae. All species present in the study area are characterized by the dorsiventral, whitish, grayish, greenish or olivaceous thalli. In this framework, the Parmeliaceae are distinguished from the Physciaceae by exhibiting larger, thicker thalli, broader lobes and smooth, shiny upper and lower surfaces.

With a little bit of training it is possible to differentiate easily both families, therefore the Physciaceae and Parmeliaceae will be analyzed separately. It should be pointed out that the following discussion takes into account all the possible difficulties that could be found during fieldwork. It must be remembered the importance of collecting small samples for further examination in the laboratory in case of any doubt.

1.1. Physciaceae

1.1.1. Species with K- thallus lacking rhizines (*Hyperphyscia* spp.). In Buenos Aires City there are three species with these features: *H. syncolla*, *H.* cf. *coralloides* and *H. adglutinata*. In the present work, all specimens lacking vegetative propagules are referred to as *H. syncolla* spec. coll.*. *H.* cf. *coralloides* is the smallest species; however, frequently it forms patches of variable extension by coalescence of individual thalli. Sometimes, lobes are mostly adnate, and if granules are extremely scarce and small, specimens can be confused with small thalli of *H. syncolla*. When granules are too numerous, it may be difficult to distinguish their marginal origin. If granules are too small, they may look like soredia because the corticate condition cannot be observed in the field. When sterile, as appears in the study area, *H. coralloides* is not distinguishable from *H. pseudocoralloides* Scutari (they differentiate by the spores: 4-cellular vs. 2-cellular, respectively). However, *H. coralloides* is present in surrounding areas, while *H. pseudocoralloides* is known only from Brazil (Scutari, 1997). *H. adglutinata*, instead, is distinctly sorediate. It is also a small species and may form patches. Both position and shape of soralia may be obscured by coalescence; therefore, the whole patch must be carefully examined until some isolated soralia are found.

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* In earlier papers (Scutari 1992b, 1995), specimens with coloured medulla were treated under *Hyperphyscia endochrysea* (Krempelh.) Moberg.

1.1.2. Species with K- thallus and with rhizines (*Pyxine* spp.). The sorediate species are not always easy to differentiate, mainly when thalli are very small. The other remark concerns *P. petricola.* Only two specimens were found. The only fertile specimen was collected in the vicinity of the Buenos Aires University Campus, by the Río de la Plata coast, and had to be examined in the laboratory. The thallus was so thin that some features relevant for identification of species, such as the color of the medulla and the K reaction, could be hardly observed. However, all remaining features agreed with those of *P. petricola*: emaculate, UV+ yellow thallus, absence of vegetative propagules, narrow, linear lobes with patched, apical pruina, zeorine apothecia and white internal stipe. It should be pointed out that this is the second report of the species in Argentina. Previously, it was only cited for Corrientes Province (Ferraro, 1978), where it appears to be a quite frequent species.

1.1.3. Species with K+ yellow thallus, lacking rhizines (*Dirinaria* spp.). There are only two species in the City: *D. applanata* and *D. picta*. Thalli are always very small, quite difficult to identify.

1.1.4. Species with K+ thallus, whitish underside with rhizines, K+ or K- medulla, and marginal soralia. There are three species exhibiting these features: *Physcia crispa, Physcia sinuosa* and *P. undulata*. The first species has K- medulla, while in the others it is K+ citrine-yellow. Concerning the test with K, we have observed that, contrary to Moberg (1977), in species with K- medulla the reaction is always negative even if the algal layer is not completely removed. The only care is that the reagent must not reach the borders of the area of exposed medulla. Otherwise, the upper cortex (which is always K+ yellow) could be involved. This is an important fact, particularly for species with K+ medulla and thin and/or fragile thallus, because many times attempts of complete removal of algal layer lead also to the removal of medullary tissue, with the consequent risk of getting a false K- reaction. Another feature difficult to interpret is the epinecral layer. It develops by death of terminal cells of the cortical hyphae. Dead cells accumulate in the thallus surface forming monticules responsible for the sky-bluish tinge and the granular-frosted appearance. The epinecral layer of *P. undulata* can be distinguished in the field (magnification not less than 10x). It must be mentioned that, sometimes, thalli of *P. crispa* may be also sky-bluish and exhibit a granular upper surface. This fact may lead to misidentifications in the field. However, in these cases it is consequence of farinose, dull pruina. On the other hand, *P. sinuosa* may exhibit dull, very fine pruina too. To avoid confusions, it is important to check the K reaction of the medulla and to observe very carefully the shape of soralia, taking into account the combination of features given in Table 2.

TABLE 2. Comparison among *Physcia crispa*, *P. undulata* and *P. sinuosa*.

	P. crispa	*P. undulata*	*P. sinuosa*
Upperside	sky-blue grayish, farinose	sky-blue grayish, farinose-frosted	grayish-green, smooth
Epinecral layer	absent	present	absent
Pruina	dull, farinose	absent	occasional, dull, fine
Medulla	K-	K+ citrine yellow	K+ citrine yellow
Soralia	marginal (lateral), linear, short	marginal (axilar), hemiorbicular	marginal (axilar), hemiorbicular
Margin of lobes	crisped	undulate (upper cortex revolute)	undulate (upper cortex revolute)

1.1.5. Species with K+ thallus, whitish, rhizinate underside, lacking vegetative propagules (*Heterodermia diademata*, *Physcia aipolia*, *P. alba* and *P. biziana*). These species were quite difficult to differentiate in the field, particularly the mentioned *Physciae*, which are currently being revised by the first author taking into account the following differential characters: 1) presence/absence of maculae, abundance and distribution pattern on the upperside (numerous, uniformly distributed vs. scarce, irregularly distributed), shape and relative size (punctiform, inconspicuous vs. allantoid, almost visible with naked eye); 2) presence/absence of pruina, type (farinose vs. shiny) and density (scarce vs. abundant); 3) upper surface (rugose vs. smooth); 4) shape of lobes (linear vs. flexuous); 5) shape of lobe apices (truncate to spatulate vs. broadened to flabelliform); 6) color and K reaction of medulla (white, K-; or snow-white, K+ citrine yellow; or whitish, K+ intensification of tinge); 7) surface of lobes (plane vs. convex); 8) thallus color (pale sky-blue-grayish, dark greenish-gray or dark gray); 9) thallus structure. Problems arose with some distinctly maculate specimens (*P. aipolia* morphotype) because of an unexpected K- medullary reaction, and some pruinose specimens (*P. biziana* morphotype) with apparently K+ medulla. A fourth, undescribed species could be involved.

1.2. Parmeliaceae

In the study area, the Parmeliaceae are considerably less abundant than the foliose Physciaceae (34,4 % vs. 56,2 % of foliose species, respectively), and usually their thalli are larger and more loosely attached than those of the Physciaceae. Therefore, the identification of species in the field is much easier. Thalli are either grayish or greenish, with dark-brown, rhizinate underside (rhizines usually visible with 10x or less magnification). Species are divided here in two groups:

1.2.1. Pseudocyphellate species. We found only two species with pseudocyphellae: *Punctelia constantimontium* and *P. microsticta.* The former species produces phyllidia, usually very abundantly, while the latter exhibits no vegetative propagules. Young thalli of the Parmeliaceae do not always develop propagules immediately, so that if we are dealing with small non-phyllidiate thalli (supposed to be young) it is advisable to check the C reaction in the medulla: *P. constantimontium* is C+ pink to red, while *P. microsticta* is C-

1.2.2. Species lacking pseudocyphellae. In this group, the only problematic species are those with emaculate, eciliate thallus, belonging to the genus *Canoparmelia*. In the City we found three species: *Canoparmelia carneopruinata* and *C. crozalsiana*, with K+ yellow medulla, and *C. texana*, with K- medulla. The only difficulty is to identify small thalli with K+ medulla, because *C. carneopruinata* and *C. crozalsiana* differ only by the width of lobes and degree of attachment to the bark. According to Adler (pers. comm.), most likely *C. carneopruinata* will be regarded as synonymous of *C. crozalsiana* in the near future.

1. Crustose lichens

Usually, many of these species may be easily overlooked during ecological surveys because of their inconspicuous size. Actually, some species were found accidentally during preliminary surveys, when examining in the laboratory samples of other species. Such are the cases of *Scoliciosporum chlorococcum*, collected along with *Bacidia heterochroa*, and *Buellia* spp., collected along with *Rinodina insperata*, *Dimerella pyrophthalma* and *Lecanora argentata*. Hence it is very important to examine the whole trunk with hand lens of progressively higher magnifications.

It should be pointed out that the crustose Physciaceae can be distinguished in the field by dark color of the mass of spores (visible in sectioned apothecia with 20x). This feature allows one to differentiate, on one hand, *Rinodina insperata* from *Lecanora argentata* and *Caloplaca* sp. 1, and on the other hand, *Buellia* from *Bacidia* and *Scoliciosporum* spp. We would like to stress, however, that the collection of small samples for confirmation of field identifications should never be excluded. The most problematic species are the following:

2.1. Species with yellowish to red, K+ purple discs (*Caloplaca erythrantha*, *Haematomma subinnatum*). Apothecia of both species are seen at first glance as colored spots on a grayish background. They can be distinguished only by examining the type of spores: ellipsoid, polar-2-locular in *Caloplaca erythrantha* vs. filiform, pluricellular, transversely septate spores in *Haematomma subinnatum*. Nevertheless, it should be pointed out that the apothecia of *H. subinnatum* are much smaller, and their thalline margin can be distinguished only with high magnification (10x), while in *C. erythrantha*, the thalline margin is usually visible with 2x.

2.2. Species with dark-brown apothecial discs (*Rinodina insperata*, *Lecanora argentata*, *Caloplaca* sp. 1, *Bacidia heterechroa*, *Scoliciosporum chlorococcum*, and *Buellia* spp.). The first three species exhibit lecanorine apothecia. *Lecanora argentata* and *Caloplaca* sp. 1, with grayish to greenish, continuous to fissured, well developed thalli, can be accurately differentiated only by the spore-type: unicellular vs. polar-2-locular, respectively. Concerning *Rinodina insperata*, the lecanorine nature of apothecia is frequently obscure (apothecia very small, only visible from 10x, with very thin thalline margins). However, with some practice the species can be readily recognized by sectioning an apothecium to verify the dark color of the hypothecium and the presence of dark dots in the hymenium (spores). It could be added that the thallus is whitish, continuous, and very poorly developed. *Bacidia heterochroa* is distinguished by the lecideine apothecia. This is also the case for *Scoliciosporum chlorococcum* and *Buellia* spp., the most inconspicuous species in the City; they can be differentiated only by the spore-type (colourless, filiform, transversely septate vs. brownish, polar-2-cellular spores, respectively).

CONCLUSIONS

A list of 50 species of epiphytic lichens from Buenos Aires City is presented, determined according to most modern taxonomic concepts. In some few cases, determination at species level was not possible due to the scarcity of material, even with the help of the corresponding specialists. *Teloschistes chrysophthalmus* and *Haematomma subinnatum*, registered during a preliminary survey in 1984, are probably already extirpated. *Ramalina celastrii* and *Xanthoria fallax*, instead, could have survived in the parks of the south of the City. There were several interesting records. *Scoliciosporum chlorococcum*, previously unknown in South America, is a common toxitolerant species in polluted areas of the Northern Hemisphere (Le Blanc & De Sloover, 1970: as *Bacidia chlorococca*; Nimis et al., 1990) but very rare in the study area. Another two species, *Pyxine petricola*, cited only for Corrientes Province by Ferraro (1978), and a probably undescribed species of *Caloplaca* present also in Uruguay (Osorio, pers. comm.), are reported for the pampa region for the first time. Likewise, the finding of an *Endocarpon* species should also be emphasized, mainly because the corticolous taxa are rather uncommon in the Verrucariaceae (Heidmarsson, in litt.). Regarding the key, it was demonstrated to serve very well its main goal since it was tested in the field (under close supervision) by the second author while still an inexperienced student. Moreover, the inclusion of species found in surrounding urban areas make this key also applicable for monitoring studies in the "Gran Buenos Aires" region.

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A NEW SPECIES OF GLOIOCEPHALA FROM COLOMBIA

Ruth Aldana-Gómez
Biological Sciences 066 , University of Illinois at Chicago
845 W Taylor. Chicago, IL 60607, USA
Botany Department, Field Museum of Natural History
1400 S. Lakeshore Drive. Chicago, IL 60605, USA
e-mail: raldan1@uic.edu

Ana E. Franco-Molano
Biology Department, University of Antioquia
A.A. 1226 Medellin, Colombia.
e-mail: afranco@catios.udea.edu.co

ABSTRACT: An interesting agaric with a marasmioid habit was collected in *Quercus humboldtii* forests in western Colombia. The basidiocarp is relatively large, pure white, and viscid. The numerous capitate cystidia in the epicutis, hymenium, and stipe coupled with the macromorphological characteristics suggest that it is a new species of *Gloiocephala*.

KEY WORDS: capitate cystidia, *Marasmius*, *quercetorum*, *Quercus*, Agaricales.

Explorations of Colombian montane and dry forests have yielded many new species of Basidiomycetes (Halling, 1989; Franco-Molano, 1999; Hjortstam & Ryvarden, 2000). In this paper we describe a new species of *Gloiocephala* Mass. encountered during fieldwork in the montane *Quercus*-dominated forests of western Colombia.

Color designations in alphanumeric form within parentheses are from Kornerup and Wanscher (1983). Line drawings were made with the aid of a drawing tube. All measurements of micromorphological structures were made in 3% KOH. Q represents the mean length/width ratio of 30 basidiospores.

Gloiocephala quercetorum Aldana-Gómez & Franco-Molano, *sp. nov.*
Figs 1 & 2.

Pileo albo, convexo vel expanso, 2-40 mm lato; lamellis albis, distantibus; stipite albo, centrali, excentrico, 10-35 mm longo. Basidiosporis (6-) 7-10 x 3-4 µm; dermato- et hymenocystidiis capitatis vel ventricoso-subcapitatis. Ad folia ***Quercus humboldtii*** *Bonpl. in Colombia.*

HOLOTYPE: COLOMBIA. DEPARTAMENTO DE ANTIOQUIA. Municipio

Santa Rosa de Osos, vereda Vallecitos 6°42'51" N, 75°28'77" W. 2540 m above sea level. 14 October 1998. Marcela Zalamea 156 (A.E. Franco-Molano, C. López & D. Restrepo) (HUA), ISOTYPE (F).

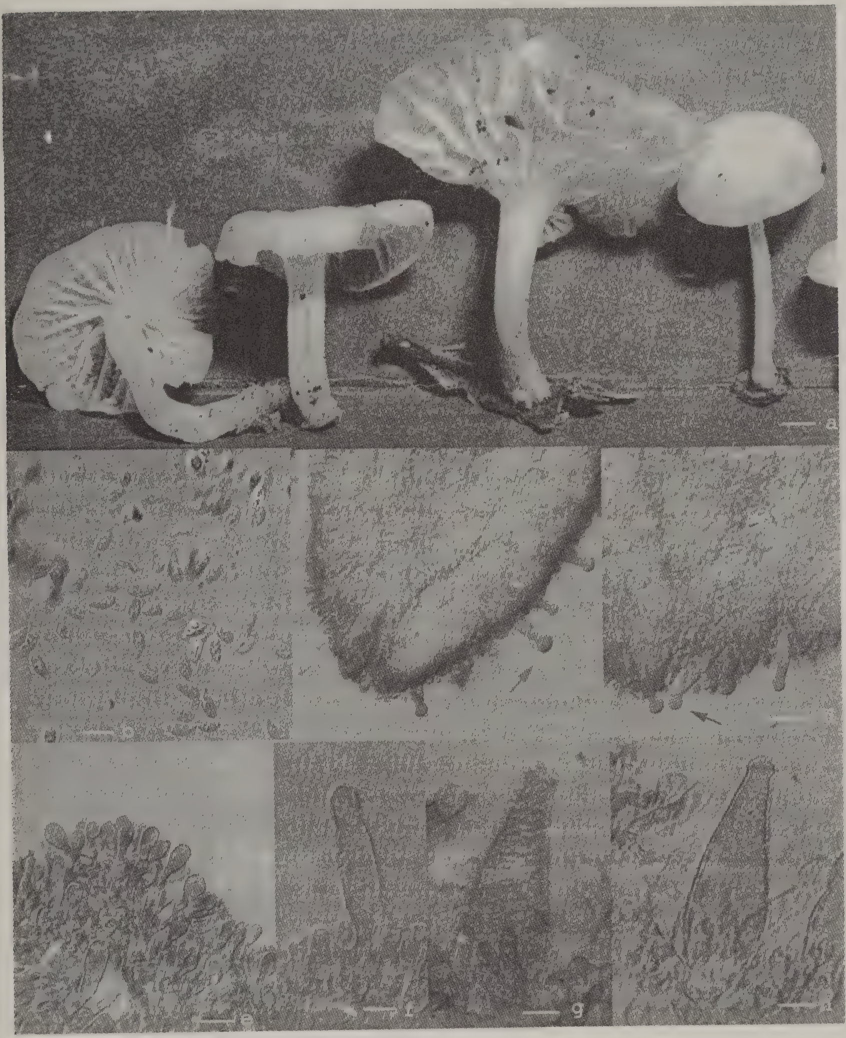
ETYMOLOGY: Growing in *Quercus* forest.

Pileus 2-40 mm diam, convex when young, plane and uplifted with age, depressed at the center, surface sulcate, translucid, glabra to minutely hispid, viscid to dry, white when fresh, pinkish-yellow (5B4) at the center, light brown (6D4) toward the margin when dried. **Context** thin (<1mm), white. Odor and taste not distinctive. **Lamellae** reduced, interveined, subdecurrent, white to light pinkish-brown when dried, subdistant. **Stipe** 10-35 mm long, 2-6 mm wide near the apex, white, central to excentric in some collections, surface minutely pubescent to glabrous at the apex, almost strigose to substrigose toward the base, cilindric or somewhat plane, straight, bending with age. Pale yellow mycelium at the base.

Basidiospores white in mass, (6-) 7-10 x 3-4 µm, Q= 2.13, ellipsoid to cylindrical, inequilateral in profile, smooth, thin-walled, hyaline in H_2O and KOH, inamyloid in Melzer's reagent. **Basidia** 28-35 x 8-9 µm, narrowly clavate, 2-4 sterigmata, hyaline in KOH, inamyloid in Melzer's reagent. **Pleurocystidia** 34-96 x 10-12 µm, ventricose, mostly capitate, capitulum 9-11 µm wide, thin-walled, hyaline in KOH, inamyloid in Melzer's reagent. **Cheilocystidia** 48-65 x 10-13 µm, clavate, some capitate, thin-walled, hyaline in KOH, inamyloid in Melzer's reagent. **Pileipellis** hymeniform, consisted of pyriform and pedunculate smooth elements, 17-40 x 10-12 µm, thin-walled, hyaline in KOH, dermatocystidia among these pyriform cells, 30-35 x 12 µm, ventricose, capitate, some with a helicoidal ornamentation and/or apical incrustation, thin- or subthick-walled. **Pileus trama hyphae** very thin, gelatinous, thin-walled, nonincrusted, hyaline in KOH. **Stipe trama** parallel, cylindric, hyaline in KOH. **Stipitipellis** composed of caulocystidia 21-72 x 8-14 µm, versiform, pyriform, ventricose, with either an obtuse or capitate apex, thin-walled, nonincrusted, hyaline in KOH, inamyloid in Melzer's reagent. **Clamp connections** absent, some pseudoclamps present.

Substrata: Scattered to gregarious on *Quercus* leaves.
Distribution: Known only from Colombia and Costa Rica.

Fig. 1. a. Basidiocarps of *Gloiocephala quercetorum sp. nov.*; M. Zalamea 156, scale bar = 5mm.
b-h. Micromorphological features of *G. quercetorum,* M. Zalamea 156: a. basidiospores, scale bar = 8µm. c and d. lamellae section showing pleuro and cheilocystidia, scale bars = 15µm and 20µm respectively. e. pileipellis elements, scale bar = 50µm. f-g. scalp section of pileipellis showing the types of dermatocystidia, f. apical incrusted, scale bar = 11µm, g. with helicoidal ornamentation (out of focus to show ornamentation), h. the same as previous, scale bars = 17µm.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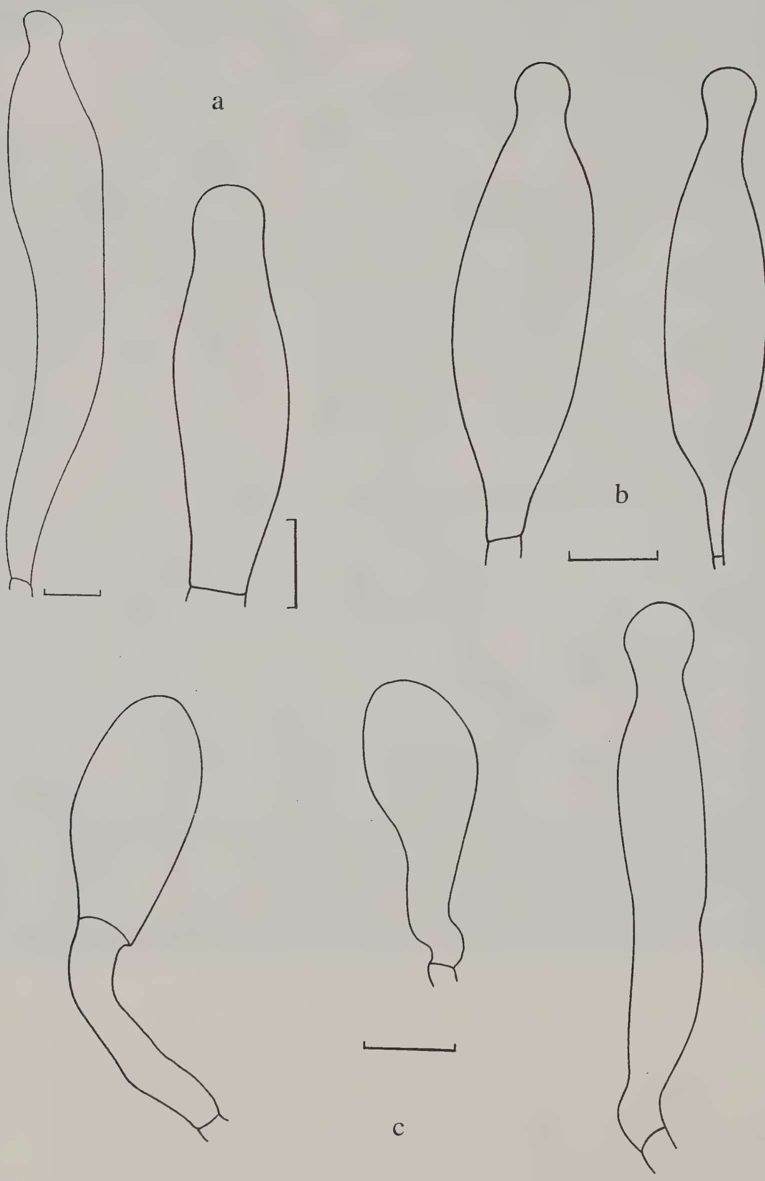

Fig. 2. Micromorphological features of *Gloiocephala quercetorum*, M. Zalamea 156: a. Pleurocystidia. b. Queilocystidia. c. Caulocystidia. Scale bars = 10µm.

MATERIAL EXAMINED: COLOMBIA. DEPARTAMENTO DE ANTIOQUIA. Municipio Santa Rosa de Osos, Vereda Vallecitos, 6°42'51" N, 75°28'77" W. 2540 m above sea level. 12 April 1999, R. Aldana- Gómez 179 (P. Trujillo & C. López)(HUA). 2 May 1999, P Trujillo 387, 388, 390 (R. Aldana- Gómez & C. López)(HUA). 28 May 1999, P. Trujillo 447, 451 (R. Aldana- Gómez & C. López)(HUA). 10 September 1999, P. Trujillo 497 (R. Aldana- Gómez & C. López)(F). Municipio Belmira, Puerto Nuevo, Vereda La Salazar, Finca La Alvessi. 10 April 1999, R. Aldana- Gómez 125 (P. Trujillo & C. López)(F). 11 April 1999, R. Aldana- Gómez 160 (P. Trujillo & C. López)(F), P. Trujillo 280, 281 (R. Aldana- Gómez & C. Lopez)(HUA). 10 June 1999, P. Trujillo 475 (R. Aldana-Gómez & C. López)(HUA).

EXTRALIMITAL MATERIAL EXAMINED: COSTA RICA. Bosque del Niño, R.F. Grecia. 29 July 1994, J.L. Mata 143 (USJ). 2 September 1994, J.L. Mata 232 (USJ). 23 September 1994, J.L. Mata 306 (USJ). 13 July 1995, J.L. Mata 685 (USJ). 3 August 1995, J.L. Mata 746 (A. Franco-M., J. Carranza & J. Torres)(USJ). 10 August 1995, J.L. Mata 762 (USJ). 7 September 1995, J.L. Mata 809 (USJ).

Species of the genus *Gloiocephala* have small to very small carpophores with a smooth, or vein-like, or merulioid or lamellate hymenophore, a hymeniform epicutis, hymenial and dermatocystidia that are frequently capitate, and a long and gelatinous pileus trama (Singer, 1986). Other concepts developed by some authors do not recognize these attributes as significant and place *Gloiocephala* as a section in the genus *Marasmius* (Noordeloos, 1981, 1987; Antonín & Noordeloos, 1993), however in this treatment we followed the generics concepts stated by Singer (1960, 1986).

Despite its large size, *Gloiocephala quercetorum* displays a number of features that support its inclusion in the genus, a pileipellis formed by pyriform cells and capitate and ventricose hymenial and dermatocystidia, and gelatinous pileus trama.

Gloiocephala quercetorum belongs in section *Gloiocephala* sect. *Confusae* Singer and appears quite similar to *G. confusa* Singer and *G. epyphilla* Mass. However, the latter two species have smaller basidiomes. In addition *G.confusa* has shorter cystidia than *G. quercetorum*, and *G. epyphilla* has a smooth hymenophore and longer dermatocystidia.

While new species within *Gloiocephala* are being described (e.g. Desjardin & Horak, 1997; and this paper), the status of the genus remains controversial (Singer, 1960, 1986; Noordeloos, 1981, 1987; Antonín & Noordeloos, 1993). Thus, further studies on cystidial morphology in the group, coupled with molecular analyses to assess the monophyly of the genus and species relatedness are needed.

ACKNOWLEDGMENTS

A number of people helped with field work and/or made the specimens available to us including Carlos López, Marcela Zalamea, Pioquinto Trujillo, Daniel Restrepo and

Julieta Carranza. Fernando Fernández advised in taking micromorphological data on specimens. We thanks Laura Guzmán, Greg Mueller and Fernando Fernández for reviewing this manuscript. This paper is based on work supported by Grant No. 1115-13-141-96-Colciencias awarded to the University of Antioquia.

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PODAXIS ARGENTINUS AND OTHER SPECIES OF PODAXACEAE FROM CATAMARCA, ARGENTINA

Mª. M. DIOS [1], G. MORENO [2], A. ALTÉS [2]

(1) Departamento de Biología, Facultad de Ciencias Exactas y Naturales, Universidad Nacional de Catamarca, Avenida Belgrano 300, 4700 San Fernando del Valle de Catamarca, Catamarca. Argentina. E-mail: mariamartha01@uol.com.ar

(2) Departamento de Biología Vegetal, Universidad de Alcalá, 28871 Alcalá de Henares, Madrid. España. E-mail: gabriel.moreno@uah.es

ABSTRACT

The first records of *Podaxis argentinus* from the province of Catamarca, Argentina, are described and illustrated here. The observation of their spores under SEM confirms one of the main distinctive features: the presence of a small germ pore. In addition, two other species of Podaxaceae from this province are illustrated with SEM: *Gyrophragmium dunalii* and *Montagnea arenaria.*

Key Words: corology, *Gyrophragmium, Montagnea, Podaxis*, taxonomy.

INTRODUCTION

The province of Catamarca is located in the Northwest of Argentina, between 25° 12' and 30° 40' South and from 64° 55' to 69° 28' West. It covers an area of 102,602 Km², 70% of which is mountainous.

The studied area consists of the Capital and Tinogasta departments. The phytogeographical district corresponds to the Chaqueño Domain. The first phytogeographical province is the Chaqueña, which includes the Arid Chaco District. The climax wood is an open wood of *Aspidosperma quebracho-blanco* Schltdl. (white quebracho) and *Prosopis nigra* Hieron. (black algarrobo). This district has been drastically modified by the presence of shrubs consisting of thorny Fabaceas and *Larrea sp.* (jarilla). The second phytogeographical province is the Monte Province. Within the sampling area there is an open wood of *Prosopis flexuosa* DC. that shares the same habitat with a sparse undergrowth of *Atamisquea emarginata* Miers (atamiski) and *Suaeda divaricata* Moq. (jume), called "comunidad del algarrobal".

About the taxonomy of the studied genera, we follow Hawksworth *et al.* (1995), who classify them in the order Agaricales, family Podaxaceae.

MATERIAL AND METHODS

The studied material is kept in the herbarium of the Universidad de Alcalá (AH), Spain, and in the personal herbarium of one of us (Mª.M. Dios), currently deposited in the Department of Biology, at the College of Natural and Exact Sciences, Universidad Nacional de Catamarca, Argentina. Furthermore, small portions of the specimens are preserved in semipermanent preparations in Hoyer´s medium.

The samples have been mounted in water, Melzer's reactive or ammoniacal congo red solution to observe them under light microscope (LM). The photographs with scanning electron microscope (SEM) were made according Moreno *et al.* (1995).

SPECIES

Podaxis argentinus Speg., *Anales Mus. Nac. Buenos Aires* 6: 186. 1898 (as Podaxon). FIGS. 1-4

= *Podaxon patagonicum* Speg., *Anales Mus. Nac. Buenos Aires* 6: 186. 1898.

Material studied: Capital department, marginal area of the "La Aguada" trash dump, humus of *Prosopis nigra* and *Larrea cuneifolia*, *Mª.M. Dios*, 07-III-2001, AH 19631, *duplo in* Herb. Mª.M. Dios 54. Tinogasta department, Medanitos, wood in the sources of the Abaucan river, in *Prosopis flexuosa* wood, *R. Salinas*, 14- XI- 1998, Herb. Mª.M. Dios 55, *duplo in* AH 19632.

Observations: *Podaxis argentinus* is morphologically identical to *P. pistillaris* (L.: Pers.) Fr. Our two collections are formed by basidiocarps of

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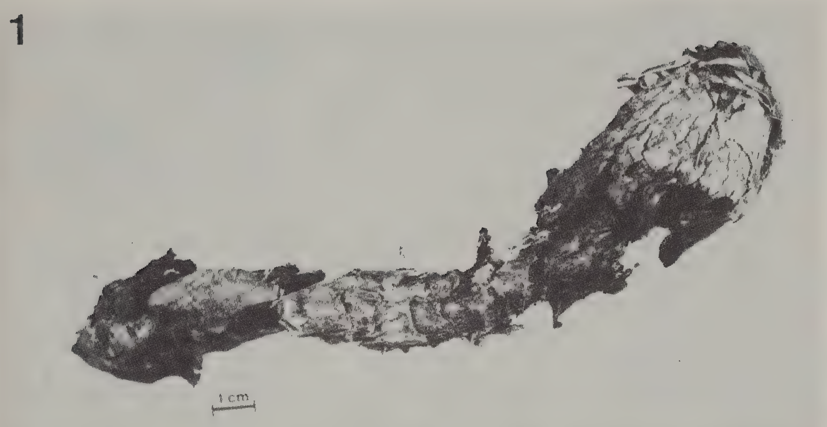
FIGS. 1-4. ***Podaxis argentinus*** AH 19631. FIG. 1. Basidiocarp. FIGS. 2-4. Basidiospores with small germ pores under SEM. FIG. 5. ***P. pistillaris*** AH 18592. Basidiospore with a big germ pore under SEM.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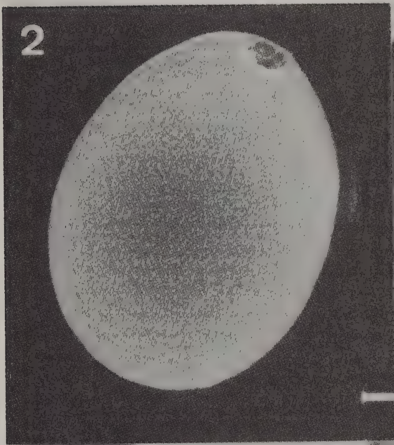
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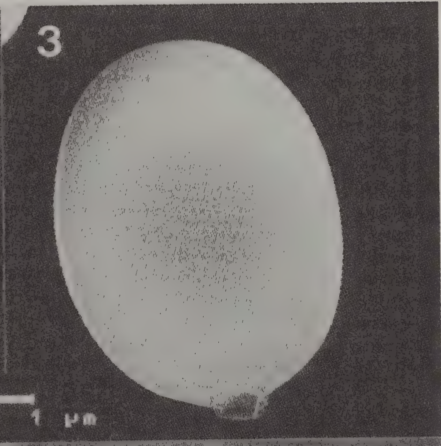
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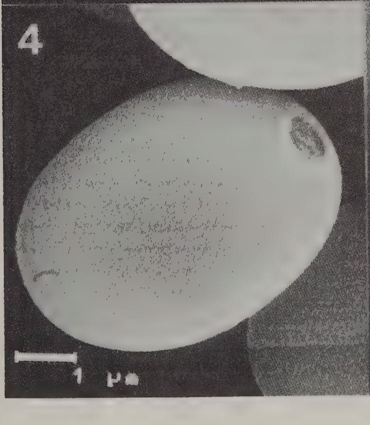
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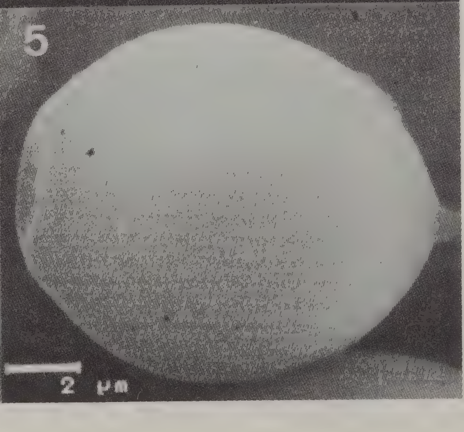
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200-280 mm high, one of which still has its closed and complete pileus (Fig. 1), measuring 60 x 35 mm, cylindrical, with a narrower, more obtuse apex, chestnut white colored, with scales. The columella is well developed, reaching the apex of the basidiocarp. Stem up to 140 mm long and 15-40 mm diam., woody, light brown, fistulose, squamose and radicating. Spores 5-8 x 4-5 µm, globose to ellipsoidal, with a not very conspicuous germ pore (Figs. 2, 4), which is often difficult to observe under LM.

The few authors that have studied this species and compared it with *P. pistillaris*, have not yet reached an agreement about the differences between these two species. Morse (1941) suggests, based on his bibliographical studies but without reviewing the type material, a possible synonymy between *P. pistillaris* and *P. argentinus*. Martínez (1971) does study Spegazzini's original material on which this species is based. This material contains the original drawings and annotations by Spegazzini. The spores of these specimens exhibit a thick wall and a small germ pore. Therefore, the distinctive feature of these species, following Martínez (1971), is the size of the germ pore in the spores, which is small in the *P. argentinus* and big in *P. pistillaris*. This germ pore has already been drawn by Spegazzini in the envelopes containing the material, although he did not consign it in the original description. A different position is taken by Domínguez de Toledo (1993), who, in his artificial key to differentiate the species of *Podaxis*, distinguish *P. argentinus* and *P. pistillaris* by the size of their spores and by the presence or absence of a germ pore: *Podaxis argentinus* exhibits "esporas de hasta 7.5 µm de largo promedio, sin poro germinativo" ("spores up to an average 7.5 µm long, without a germ pore").

Our observations are in line with those of the mentioned authors: the differences between these two species are essentially under microscope. The spores of *P. argentinus* are smaller than those of *P. pistillaris* (9.5-17 x 8.5-13.5 µm) (Fig. 5), and exhibit a smaller germ pore, sometimes difficult to observe under LM, which is however clearly visible under SEM (Figs. 2, 4). In our opinion, these differences are enough to maintain them as separated species. In the other hand, we accept the synonymy suggested by Martinez (1971), who, after reviewing the typus material of *Podaxis patagonicum* Speg., concludes that this species and *P. argentinus* are co-specific.

Podaxis argentinus has a wide distribution in Argentina and it appears cited in Mendoza, Salta, Rio Negro, Buenos Aires (Spegazzini, 1906),

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FIGS. 6-8. ***Gyrophragmium dunalii*** AH 19640. FIG. 6. Basidiocarps. FIGS. 7, 8. Basidiospores under SEM. FIGS. 9-11. ***Montagnea arenaria*** AH 19641. FIG. 9. Basidiocarp. FIGS. 10, 11. Basidiospores with germ pore under SEM.

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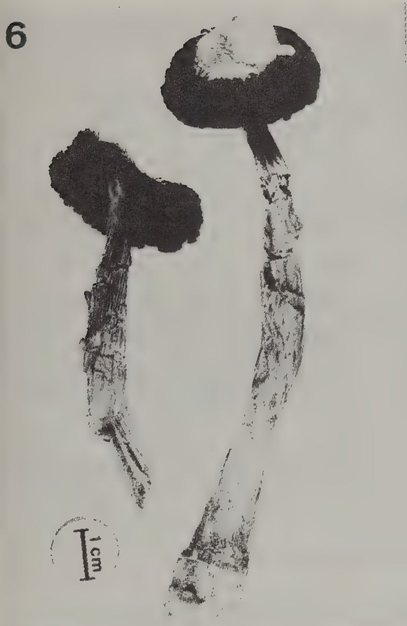

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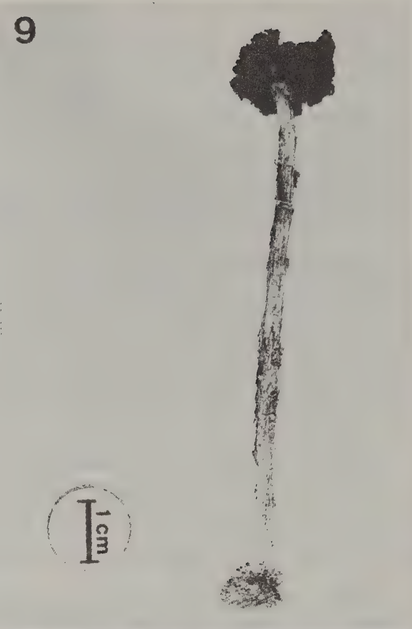

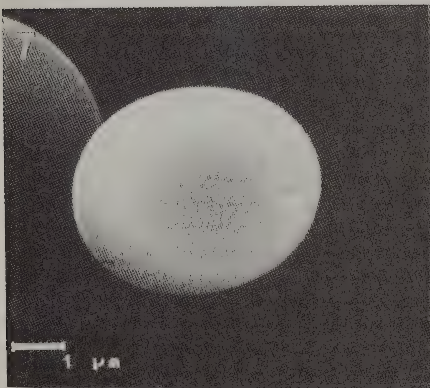

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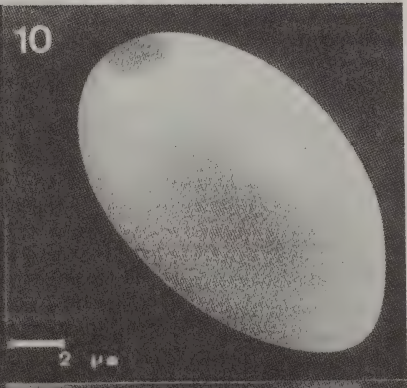

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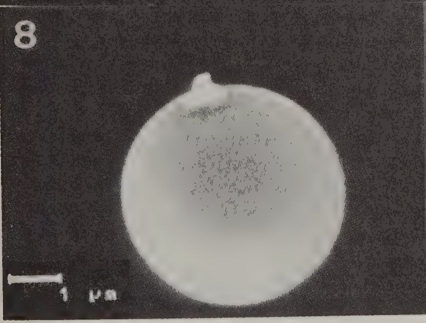

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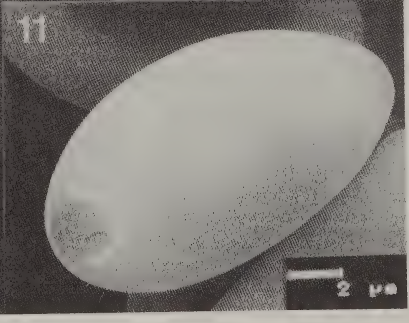

Córdoba, (Nouhra & Domínguez de Toledo, 1991), Santiago del Estero (Martínez, 1971), and San Luis (Domínguez de Toledo, 1993).

This is the first record of this species in the Catamarca province.

Gyrophragmium dunalii (Fr.) Mont., *Ann. Sci. Nat., Bot.* 20: 77. 1843.
FIGS. 6-8

^ *Montagnites dunalii* Fr., *Epicrisis*: 241. 1836.
= *G. delilei* Mont., *Ann. Sci. Nat., Bot.* 20: 77. 1843.
= *G. argentinum* Speg., *Anales Mus. Nac. Buenos Aires* 6: 185. 1898.

Material studied: Tinogasta department, Fiambalá, urban area, in sandy soil with *Pinus* sp., *Mª.M. Dios*, 15-V-1999, AH 19640, *duplo in* Herb. Mª.M. Dios 52.

Observations: This material of *Gyrophragmium dunalii* shares the typical macro and microscopical features of the species (Fig. 6). We emphasize its darkish anastomosed lamelliform hymenofore, its smooth globose spores, 5-6 µm diam., and the absence of a germ pore (Figs. 7, 8).

Gyrophragmium argentinum has been considered synonymous of *G. dunalii* by Bottomley (1948).

In Catamarca "no es raro en las arenas de los cauces de los arroyos en Piedra Blanca" ("it is not rare in the sand of creek beds in Piedra Blanca"), according to Spegazzini (1927). However, this collection develops in sandy soil but far from creek beds. This species has not yet been collected in Argentina on littoral dunes, where it is often cited in Europe. This situation is similar in some areas of Mexico, according to Guzmán & Herrera (1969).

There are few references of this species from Argentina. Records are known from Salta (Spegazzini, 1898), Catamarca (Spegazzini, 1927) and La Rioja (Domínguez de Toledo, 1989, 1993). Additionally, there exists material by Spegazzini and A. Ruiz Leal deposited in LPS from Mendoza, and by Spegazzini from Salta (Domínguez de Toledo, 1993).

This record of *Gyrophragmium dunalii* confirms its presence in Catamarca.

Montagnea arenaria (DC.) Zeller, *Mycologia* 35: 418. 1943. FIGS. 9-11

^ *Agaricus arenarius* DC., *Flore Francaise* 6: 45. 1815.
= *Montagnites argentina* Speg., *Anales Mus. Nac. Buenos Aires* 6: 160. 1898.

Material studied: Capital department, marginal area of the "La Aguada" trash dump, in the banks of the San Lorenzo creek, in sandy slimy soil, *Mª.M. Dios*, 13-III-

2001, AH 19641, *duplo in* Herb. Mª.M. Dios 53.

Observations: The studied basidiocarps of *Montagnea arenaria* collected in Catamarca share the typical macro and microscopical features of this species (Fig. 9). We emphasize its darkish lamelliform hymenofore, its ellipsoidal and smooth spores, 13-16 x 10-12 µm, dark brown to blackish brown, and with a wide apical germ pore (Figs. 10, 11).

This species is abundant in arid and subarid areas, and has a worldwide distribution. However, it has been seldom cited from Argentina. There are records from Buenos Aires (Spegazzini, 1909; Singer, 1969), Salta (Spegazzini, 1898; Singer, 1969), Catamarca and Neuquén (Singer, 1969), Chubut (Spegazzini, 1913), Mendoza (Spegazzini, 1909), Catamarca and La Rioja (Domínguez de Toledo, 1989, 1993). In addition, there exists Spegazzini´s material deposited in LPS from Catamarca, Capital department (Domínguez de Toledo, 1993).

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CALOPLACA LOBULATA OCCURRING IN TASMANIA

I. Kärnefelt

Department of Systematic Botany, the Botanical Museum, Lund University,
Östra Vallgatan 18, S-223 61 LUND, Sweden
Ingvar.Karnefelt@botmus.lu.se

ABSTRACT

An unexpected discovery of *Caloplaca lobulata* in Tasmania is presented. This species which earlier seemed rather widely spread in central Europe have today become an extremely rare and endangered element in the European lichen flora. The generic affinity with other closely related species is briefly discussed.

KEY WORDS: Teloschistaceae, endangered lichen species, Tasmania.

INTRODUCTION

This remarkable species tends to show up when carefully looked for in various localities and places. There is no indication of a continuous distribution, although the known habitat ecology seems to be eutrophic situations in the cultural landscape. The systematic position of *C. lobulata* furthermore has been argued by various authors, mainly concerning the generic affinity (Steiner & Poelt 1982). During field work in Australia and Tasmania in 1999 *C. lobulata* was found in rather abundance on twigs and bark of cultivated trees north of Hobart at Oatlands in Tasmania. *Caloplaca lobulata* has not been reported from this part of the world before.

Caloplaca lobulata (Flörke) Hellb.

Bih.K.Sv. Vetensk.-Akad. Handl. (1897) 21, 3, 13: 67, 1897.
Basionym: *Lecanora lobulata* Flörke, Deutsche Lich.(1815) 3: 14.
Xanthoria lobulata (Flörke) de Lesd., (1907): 682.

Xanthoria boulyi Zahlbr., Scaeda ad Lich. Rar. Exs. 119.
Caloplaca boulyi (Zahlbr.) M. Steiner & Poelt, (1982), Pl. Syst.Evol. 140: 151-177.

Thallus composed of tiny foliose squamules, usually occurring a few together, 0.5 – 2.0 mm large, greyish to more *Xanthoria* coloured yellowish to orange. The central portions frequently covered by numerous apothecia.

Ecology and distribution

Caloplaca lobulata was found in a rather exposed habitat in open agricultural land growing on twigs and trunks of several introduced trees, mainly *Crataegus* and *Populus nigra*. In larger areas in Tasmania north of Hobart and along the northern coast this cultivated type of landscape is rather common. The trunks of the rather well grown trees were partly covered by both *C. lobulata* and also by *Xanthoria parietina*. Lower partly dead branches were also overgrown by lichens and especially by *C. lobulata*. Many members of the genera *Caloplaca* and *Xanthoria* are favoured by fertilizers from the agricultural land which can be seen in many European countries. It is strange that *C. lobulata* was found in such an abundance in the single Tasmanian locality knowing of the quite different situation from European countries.

Since the mid of last century many single lichen species as well as whole lichen communities have been retreating presumably due to a combination of factors such as acidification and dramatic changes in the cultural landscape. Large areas of forested habitats have been destroyed and with these changes we can observe a decline in mainly corticolous lichen associations, especially those with cyanobacteria as associated symbionts. We have seen this change in most European lichen floras and it has been documented in numerous publications (Purvis 2000).

In the Nordic countries the retreat of this species along with a number of other threathened or redlisted species have been documented in detail (Arup et al 1997, Thor & Arvidsson 1999). In earlier times *C. lobulata* was apparently not too rare occurring preferably on rather thin branches of various trees and shrubs such as *Ulmus, Fraxinus, Sambucus, Crataegus, Syringia* and *Ribes*. During my years at the university Gunnar Degelius once told that he remembered having seen and collected *C. lobulata* from rich populations occurring on twigs of especially *Fraxinus,* in mainly eastern parts of Sweden but in many other areas in northern Europe as well. On several excursions together during the last decades of the last century he used to mention this, being surprised he couldn't find *C. lobulata* anymore.

Similar with the discovery in Tasmaina, *C. lobulata* was almost always collected in cultural landscape in Europe. It has been reported or listed recently in various floristic works on the European continent i.e. by Nimis (1993) for northern Italy, mainly for southern Europe by Clauzade & Roux (1985), Wirth (1995) for Baden –Württenberg and by Verseghy (1994) for Hunagry.

In several other recent and detailed floristic surveys from various European regions *C. lobulata* was, however, not reported i.e. from the British Isles by Purvis et al (1992), from Slovenia by Suppan et al (2000), from Belgium and Luxemburg by Diederich & Serusiaux (2000), or from Mecklemburg-Vorpommern by Litterski (1999). In a thorough survey of the lichen flora in Rheinland-Pfalz by John (1990) *C. lobulata* was especially noted as having disappeared from the region.

The distribution of *C. lobulata* in Europe was mapped along with the closely related species *C. persica* and *C. polycarpoides* for parts of central Asia by Steiner & Poelt (1982). However, the European distributional map is to a large part based on literature references. Presumably the species has already retreated from many of the recorded localities since then.

Taxonomic notes

The systematic position of *C. lobulata* especially related to its generic affinity and affinity with a few closely related entities has been discussed especially by Steiner & Poelt (1982), Steiner (1910), and Erichsen (1944). J•rgensen & Coppins (1983) furthermore discussed the systematic position in connection with the rather complicated nomenclature. This problem is also associated with the original definitions of the genera *Caloplaca* and *Xanthoria* (Kärnefelt 1989). *Xanthoria* was partly defined on the presence of upper and lower cortical layers and presence of rhizines for attachment, which lacked in species of *Caloplaca*. In *C. lobulata*, however, there are small tendencies towards development of a lower cortical layer and in addition the small thallus lobes which develop from the base of the apothecia, superficially remind of small lobes belonging to species in *Xanthoria*. This is the main reason why Steiner & Poelt (1982) separated *C. lobulata* along with two other species in a special section *Caloplaca* section *Xanthoriella*. There are, however, yet no other evidences from morphology, anatomy, secondary chemistry or molecular data which would support a separation of these few species entirely from the genus *Caloplaca*.

The three species included in section *Xanthoriella* i. e. *C. lobulata*, *C. persica* and *C. polycarpoides*, where all according to the authors very closely related, and they could possibly also have been treated as infraspecific taxa (Steiner & Poelt 1982). The authors, however, agreed it was better to separate them at species level for the time being. There are indeed only weak key characters to separate these taxa, of which *C. persica* might be the better defined on the 16-spored asci. *Caloplaca lobulata* and *C. polycarpoides* have both normal 8-spored asci. These two species are only separated on a wider septum, 5-7 µm in *C. lobulata*, whereas the septum is 2-3 µm wide in *C. polycarpoides*. In addition there seem to be a geographical and also ecological difference in the complex, as to *C. lobulata* is a more northern to central European element, whereas *C. polycarpoides* and *C. persica* with few exceptions occur in southern Europe and in western Asia mainly. Of habitat ecology especially between *C. persica* and *C. polycarpoides*, there seems to be a preference for occurrence on cultivated trees for *C. persica* whereas *C. poycarpoides* seems to prefer growing on bark of wild trees and shrubs.

Specimens Examined

AUSTRALIA. Tasmania. North of Hobart along A1, after Kempton, 1 km before turnoff to Oatlands, growing on *Crataegus* and *Populus nigra*. Wpt. 70. 42° 29, 59'S, 147° 11, 16 E., 1999 E I Kärnefelt 997001 (LD). **ITALY**. Sardinia. Distr. Caliari, 1989 Nimis et al (Vezda, Lich. Sel. Exs. 2355, as *C. boulyi*, LD). **SWEDEN**. Sk•ne. Trolle-Ljungby, Maglestenen, on *Ulmus*, 1939 Almborn (LD); Västmanland. Rytterne, on twigs of t, 1939 Ahlner, Hasselrot & Degelius (Magnusson, Lich. Sel. Scand. Exs. 365, as *Xanthoria lobulata*, LD). **ÖSTERREICH**. Steirmark, Ostalpen, Schladminger Tauern, Kleinsölk-Obertal, 1978 Mayrhofer (Plantae Graecences 130, *as C. boulyi*, LD).

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CANDELARIA FRUTICANS FOUND IN SOUTHERN AFRICA

I. Kärnefelt & M. Westberg

Department of Systematic Botany, the Botanical Museum, Lund University,
Östra Vallgatan 18, S-223 61 LUND, Sweden
Ingvar.Karnefelt@botmus.lu.se, Martin.Westberg@sysbot.lu.se

ABSTRACT

The distribution and habitat ecology of *Candelaria fruticans* Poelt & Oberw. is discussed and a distribution map is provided. The distribution pattern is shared by a few species occurring on both sides of the Atlantic Ocean in mainly the subtropical and tropical zones.

KEY WORDS: Distribution, Candelariaceae, Southern Africa, world.

INTRODUCTION

The genus *Candelaria* A. Massal. (Candelariaceae) is a small genus, today comprising 7 species, *C. concolor, C. fibrosa, C. callopizoides, C. crawfordii, C. sphaerobola, C. fruticans* and *C. murrayi* (Poelt 1974, Poelt & Reddi 1969, Jørgensen & Galloway 1992). Some of them are rather well known and widespread i.e. *C. concolor* and *C. fibrosa* but the genus also comprises less known species e.g., *C. fruticans* or *C. crawfordii* known from mainly tropical regions. Going through older collections of Teloschistaceae from Africa for a study on the genera in parts of the Southern Hemisphere, we came across a collection from Transvaal in South Africa, which turned out to belong to the genus *Candelaria*.

Candelaria fruticans Poelt & Oberw.

Phyton (1974)16: 202. Typus. Venezuela, Estado Merida, Sierra de St. Domingo, Paramo de Muccuchies, 35-3800 m, 1969 Oberwinkler & Poelt (Poelt 7847, GZU).

Thallus foliose, ascending. Lobes sparesely branched, 0.5-2 mm wide, often with somewhat hooded tips. Upper side yellow, paling or becoming brownish grey towards the base, sometimes with a faint pruina near the lobe tips. Upper cortex paraplechtenchymatous with irregularily rounded to elongate cells, c. 15-35 µm thick. Algal layer rather scattered. Lower side white, arachnoid, ecorticate, densely to sparsely sorediate at least towards the lobe tips, soredia powdery yellow or greenish yellow. Apothecia not seen by us, scattered, lecanorine, thalline exciple with entire to slightly crenulate margin, sorediate. Spores 8 per ascus, simple or with pseudoseptum, 15-22 X 5-7 µm (Swinscov & Krog 1988). Pycnidia appearing as raised warts on the thallus surface, darker yellow than the thallus. Conidia ellipsoid, c. 2.5-3 x 1.5 µm

Ecology and distribution

Candelaria fruticans was originally described as growing on soil and over bryophytes from a Paramo habitat in Venezuela at ca. 2000 m. alt. From the other known collections from Central and South America and Africa *C. fruticans* is known mainly from corticolous substrates. In South Africa it was collected in easternmost Transvaal on cultivated trees. This region is located on rather high altitudes overlooking the lowland savanna of Krueger National Park. The Transvaal locality nevertheless is far south of the known populations collected in east Africa. In Kenya it has been collected on twigs on deforested hillsides at ca. 2.200 – 2.300 m alt. In Peru it was collected on shrubs occurring on dry slopes at ca. 200 – 500 m alt. and in Costa Rica on dry twigs of *Cupressus* at ca. 2.150 m. alt. From the known collections and information on habitat ecology, *C. fruticans* appears to prefer corticolous habitats on rather high altitudes in mountain regions.

The rather scattered disjunct distribution from Costa Rica, Peru, Kenya and South Africa (Fig. 1) is known from other groups of lichens such as *Coccocarpia* (Arvidsson 1982) and *Dirina* (Tehler 1983), genera which mainly include tropical species. *Coccocarpia flavicans* occurs in Ecudador, Angola and Kenya at rather high elevations and *C. stellata* is found in central and South America, Kenya and Mauritius (Arvidsson 1982). In the genus *Dirina* one example is *D. approximata* occurring in Central and South America and in the northern parts of Africa (Tehler 1983). *Megalospora coccodes* ssp. *coccodes* also has a similar distribution and is known from a few scattered localities in South America and Africa (Sipman 1983). This small group of corticolous species could have a long biogeographical history being associated to evolution and development of major biota in the Southern Hemisphere. For sorediate species such as *Candelaria fruticans* with disjunt distributional patterns, however, there is always a possibility of a more recent distributional history based on its asexual reproductive pathways.

Taxonomic notes

Candelaria fruticans is characterized by the broad, ascending and slightly hooded lobes which produces soredia mainly from the ecorticate lower side. Other sorediate species included in the genus except *C. murrayi*, occurring in the Antarctic, all have more adpressed lobes with marginal to submarginal soredia (Poelt 1974). *Candelaria fruticans* is also the only species of *Candelaria* so far reported to have eight spores in the ascus. Incidentally the material from South Africa was discovered while trying to identify material of *Xanthoria ascendens* in older collections. This species was described by Kondratyuk (1997) on material from South America. *Xanthoria ascendens* and *Candelaria fruticans* in fact are morphologically similar species, although the reproductive characters in asci and conidia show that they belong to entirely different families, the Teloschistaceae and the Candelariaceae respectively. Parallel morphological development occur in various groups of lichens. The development of the very special type of hooded sorediate lobes in *Candelaria fruticans* and *Xanthoria ascendens*, similar also to *Physcia ascendens* in the Physciaceae, is quite remarkable.

Specimens Examined

COSTA RICA. Cartago Prov., 7 km NE of Cartago, Potero Cerrado, 9 55' N, 83 53' W., 2150 m, on *Cupressus* by the road, 1979 Santesson 28826 (UPS), 1979 Tibell 8444 (UPS). **PERU.** Dept. Lambayeque, Prov.Chiclayo, Cerro de Reque, 6 52' S, 79 47' W, alt. 200-500 m, on shrubs on very dry rocky mountain, 1981 Santesson & Tehler P123: 4 (UPS). **VENEZUELA.** Estado Merida. Sierra de St. Dominigo, Paramo de Mucubaji, Hänge nördlich der Passhöhe El Aguila, 1969 Oberwinkler & Poelt 7847 (GZU), La Pegregosa westlich Merida, um 2000 m, 1969 Oberwinkler & Poelt 7848 (GZU). **KENYA.** Rift Valley Province, Kajiado Distr., Ngong Hills, south of highest part, 1°26-27'S, 36°39'E, c. 2180 m alt., on Carissa edulis on a deforested hillside, 3 Jan. 1971, R. Santesson 22719 (O, UPS), 22711 (UPS). Rift Valley Province, Kajiado Distr., Ngong Hills, south of highest part, summit at south end, 1°27'S, 36°37'E, 2400 m alt., twigs of shrubs fully exposed, Dec. 1971, T.D.V. Swinscow K2/8 (O). Rift Valley Province, Kajiado Distr., Ngong Hills, south of highest part 1°27'S, 36°37'E, UTM: BJ 37 43, 2300 m alt., shrubs and rocks Feb. 1972, H. Krog K45/152.(O). **SOUTH AFRICA**. Transvaal, Pilgrims Rest District, Graskop, on planted trees in the community, 1986 Kärnefelt 861912 (LD).

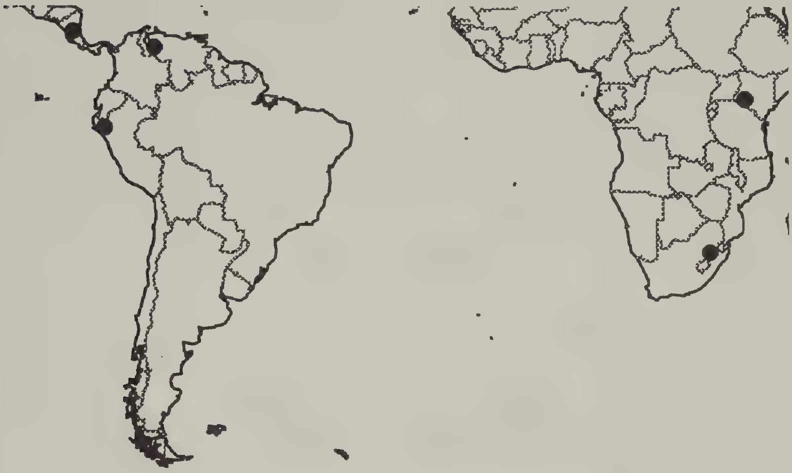

Fig. 1. Known distribution of *Candelaria fruticans*.

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LEPIOTACEAE OF FLORIDA, IV. STENOSPORIC SPECIES OF LEPIOTA S. STR.

Brian P. Akers*

and

Walter J. Sundberg

Department of Plant Biology
Southern Illinois University at Carbondale
Carbondale, IL 62901-6509

ABSTRACT

Certain species of *Lepiota* s. str. possess wedge-shaped, basally truncate basidiospores. Three such species occurring in Florida are recognized here: *Lepiota cristata*, *Lepiota truncatispora*, and *Lepiota pseudoignicolor*. This is the first account of the micromorphology of *L. truncatispora*, based upon study of the type. *L. pseudoignicolor* is reported from Florida for the first time.

Keywords: basidiospores, taxonomy, micromorphology, systematics

INTRODUCTION

Basidiospore shape is a critical taxonomic character of species in the genus *Lepiota* (Pers.) S.F. Gray sensu stricto, and has been used as a criterion for sectional definitions by various authors. One of the most unusual and distinctive variations of this character is the wedge-shaped, basally truncate type of basidiospore. This basidiospore shape is unique to certain lepiotaceous species, and has been variously described as bullet-shaped, bicornute, spurred, or stenosporic. These descriptions refer to the shape of the basidiospores as seen in profile or lateral view. The truncation of the base, which can be oblique or perpendicular to the lengthwise axis, is typically not apparent in face view. The term "spurred" generally refers to the rounded, somewhat projecting edge of the truncate base opposite from the hilar appendix. Some authors distinguish species lacking such a rounded, projecting edge of the base as having basidiospores which are basally truncate but not spurred (e.g., Bon 1981; Singer 1986).

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*Current address: Department of Biology, St. Andrews Presbyterian College, 1700 Dogwood Mile, Laurinburg, NC 28352

Species of *Lepiota* s. str. with basally truncate basidiospores have either a hymenoderm, or some variation of a fibrillose pileipellis with cylindric terminal elements. Some modern workers (Bon 1981; Enderle and Krieglsteiner 1989; Candusso and Lanzoni 1990) have placed all of these species in section *Stenosporae* (Lange) Kühner (1936). Because of the variation in the form of the pileipellis, such authors have sometimes employed a subsectional approach. For example, Bon (1981) recognizes *L. cristata* in subsection *Cristatinae* (Kühner: Wasser) Bon, and places the species with a fibrillose pileipellis in subsection *Stenosporinae* J.E. Lange.

An alternate treatment is that of Singer (1986), who placed stenosporic species with a hymenoderm pileipellis in section *Cristatae* Kühner (1936), and assigned the remainder to *Stenosporae*. Besides narrowing the concept of *Stenosporae*, this approach poses a revision of *Cristatae*. In his discussion of this arrangement, Singer (1986) states that section *Cristatae* as delineated by Kühner (1936) was "too heterogeneous", containing species having a hymenoderm pileipellis, some with ellipsoidal and others with basally truncate basidiospores. Singer (1986) notes that this problem was partially addressed by the proposal of section *Lilaceae* Bon (Bon 1981) to accomodate species with a hymenoderm pileipellis and ellipsoidal spores, but he does not extend formal recognition to this section. Singer thus maintains section *Cristatae*, but restricts it to species with wedge-shaped basidiospores and a hymenoderm pileipellis. Similarly, he reserves section *Stenosporae* for stenosporic species with a fibrillose pileipellis. Species remaining in *Cristatae* after this arrangement include *Lepiota cristata* (Bolton: Fr.) P. Kumm. and a few others such as *L. alopochroa* (Berk. & Broome) Sacc., *L. fraterna* E. Horak, *L. bichroma* E. Horak, *L. insimulata* E. Horak, and *L. aurora* E. Horak, non Murrill (Horak 1980). The nomenclature of the latter taxon is problematic because the species epithet *aurora* is previously occuppied by *L. aurora* Murrill, known only from Florida (Murrill, 1945).

Recent cladistic analysis of the ITS1/5.8S/ITS2 region of the ribosomal repeat unit suggests that the hymeniform pileipellis is a more highly conserved character in *Lepiota* s. str. than the stenosporic basidiospore shape (Vellinga and Huijser 1998). This would seem to indicate that subsection *Cristatinae* does not belong in *Stenosporae*, and that Singer was correct to limit the latter section to species with a fibrillose pileipellis. However, Singer's restriction of *Cristatae* to species with stenosporic basidiospores is not supported. Based on this molecular evidence, Kühner's initial delineation of *Cristatae* appears to gain some support, while Bon's section *Lilaceae* may warrant reinterpretation as a subsection of *Cristatae*. Vellinga and Huijser (1998) recognize *L. cristata* in a revised section *Lilaceae*, broadened to include hymenodermic species regardless of whether they have basally truncate or ellipsoidal basidiospores. This expanded concept of *Lilaceae* appears very close to Kuhner's (1936) concept of section *Cristatae*, and may be synonymous with it.

There are three species with stenosporic basidiospores that occur in Florida: *Lepiota cristata*, *Lepiota truncatispora* Murrill, and *Lepiota pseudoignicolor* Dennis. The present article offers descriptions and illustrations of the morphology of these species as they occur there. One other species occurring in Florida, *Lepiota citrophylla* (Berk. & Broome) Sacc., can display some degree of basal truncation in some of its basidiospores, but most are ellipsoidal, and this species is usually recognized in section *Ovisporae* (J.E. Lange) Kühner (Akers and Sundberg 1998; Bon 1981). This is the first account of the micromorphology of *L. truncatispora*, based upon study of the holotype, and the first subsectional classification of this species. *L. pseudoignicolor* is reported from Florida for the first time.

MATERIALS AND METHODS

The holotype of *Lepiota truncatispora* was borrowed from the FLAS mycological herbarium (University of Florida). *Lepiota cristata* and *Lepiota pseudoignicolor* were determined from field collections. Herbarium abbreviations used follow Holmgren *et al*. (1990). Taxonomic authors are abbreviated according to Kirk and Ansell (1992), and abbreviations of Latin terms follow Stearn (1992).

Small tissue samples were excised, wetted in 95% ethanol, then revived in water. Sections were cut by hand and mounted in 3% KOH and Melzer's reagent, following standard mycological methods (Smith 1949; Largent *et al*. 1977; Singer 1986). Studies of micromorphological features were carried out at 400 and 1000 X, and line drawings were made using a Leitz drawing tube. Sketches of basidiomata were executed freehand. Size ranges of elements were based on ocular micrometer measurements of at least 12-15 examples of each type from each collection studied. Wall thickness of the basidiospores is illustrated in only one example for each species. Colors noted in descriptions are personal interpretations, followed by references in parentheses to approximately equivalent centroid colors of the ISCC-NBS illustrated color name charts (Kelly and Judd 1965).

RESULTS

Lepiota cristata (Bolton: Fr.) P. Kumm., Der Führer in die Pilzekunde: 137 (1871) Fig. 1
= *Agaricus cristatus* Bolton: Fr., Syst. Mycol. 1: 22 (1821)

Macromorphological features: **Pileus** 1.8-4 cm broad, convex to broadly campanulate, slightly umbonate; cuticle glabrous, light tan brown to ochraceous (ISCC-NBS 68, 69), disrupted concentrically into flat squamules; lamellae whitish. **Stipe** pallid, length up to 5.5 cm, diameter 2-3 mm, equal, straight to barely flexuous; annulus membranous, tattered, fragile, whitish.

Micromorphological features: **Basidiospores** (Fig. 1D) 6.6-9.4 x 2.6-3.5 μm ($Q = 2.42$); wedge-shaped, narrow and subtriangular to bullet-shaped or footprint-shaped with base truncate and spurred, hilar appendix fairly prominent, wall smooth, thick (0.5 μm), germ pore

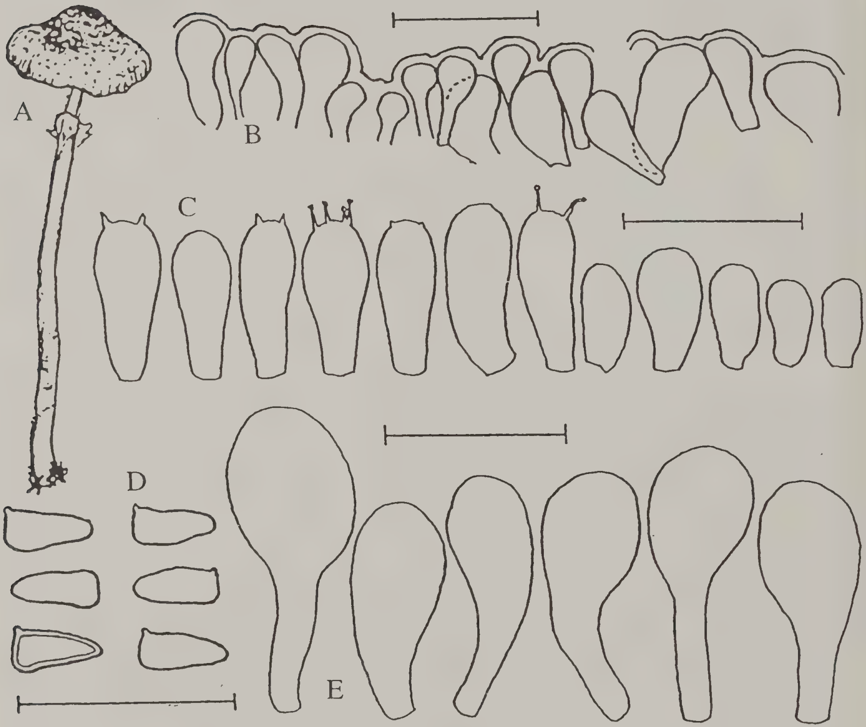

Fig. 1. *Lepiota cristata* (Bolton: Fr.) P. Kumm. A. Basidioma in fresh state, actual size. B. Pileipellis. C. Hymenial elements including basidia and basidioles. D. Basidiospores. E. Cheilocystidia. All illustrations SIUC BPA 92-07-01-008. Scale bars = 20 μm.

none; hyaline in KOH, weakly dextrinoid (pale orange brown in Melzer's reagent), not metachromatic. **Basidia** (Fig. 1C) 12-13 x 6-7.3 µm; basidioles 9.7-19.4 x 4-6.6 µm; all hymenial cells hyaline in KOH. **Cheilocystidia** (Fig. 1E) 23.3-35.2 x 7.9-11.9 µm, abundant, clavate, walls smooth, thin-sturdy, hyaline in KOH. **Pleurocystidia** lacking. **Pileipellis** (Fig. 1B) hymeniform, elements 16-38 x 6-11 µm. **Clamp connections** absent.

Collection studied: USA, FLORIDA. Alachua Co., San Felasco Hammock State Preserve, 4.5 miles WNW of Gainesville, terrestrial, scattered to gregarious to slightly cespitose in humus under hardwoods, 1 July 1992, *B. Akers*, coll. and det., SIUC BPA 92-07-01-008.

Comments. This is a widely distributed and frequently collected species, recognized by its combination of a hymeniform pileipellis and wedge-shaped basidiospores. It displays considerable variation, and Bon (1981) recognizes several varieties occurring in Europe. Color photographs of *L. cristata* are presented in Bessette (1988), Bessette *et al.* (1997), Breitenbach and Kränzlin (1995), Courtenay and Burdsall (1982), Dähncke and Dähncke (1979), Dickinson and Lucas (1979), Gerhardt (1981), Huffman *et al.* (1989), Lincoff (1981), Moser and Jülich (1985), Pacioni (1981), and Phillips (1991).

There is considerable nomenclatural confusion surrounding this species. Murrill (1914, 1949) referred to it as *Lepiota conspurcata* (Willd.) Morgan. Morgan (1906) however used that name in reference to a species he described as having ellipsoidal basidiospores, yet he listed it as a synonym of *Agaricus cristatus* Bolton. Murrill described the basidiospores of what he called *L. conspurcata* as "variable, pointed at one end and obtuse or truncate at the other" (1914: 57) so his usage is consistent with the species described here, but not with Morgan's concept of *L. conspurcata*. Morgan apparently used the name *Lepiota angustana* Britzelm., Dermek. & Melhus in reference to the stenosporic species described here. He commented that it had "spores pointed at one end and obtuse of (*sic*) truncate at the other" and cited it as "probably common throughout the country east and south, and known as *Lepiota cristata* A. & S." (Morgan 1906: 244). Guzman and Guzman-Davalos (1992) cite *L. angustana* as a misspelling of *Lepiota augustana*.

Because of its hymeniform pileipellis and overall aspect, *Lepiota cristata* superficially resembles a number of species often classified in section *Lilaceae*. It is easily distinguished from most such species, however, by its wedge-shaped, rather than ellipsoidal, basidiospores.

Lepiota truncatispora Murrill, J. Elisha Mitchell Sci. Soc. 55: 369-370 (1939) Fig. 2

Macromorphological features: **Pileus** 1-1.5 cm broad, convex, broadly umbonate; cuticle hispid-tomentose, reddish-brown (ISCC-NBS 40), disrupted concentrically into fine, fibrillose squamules;

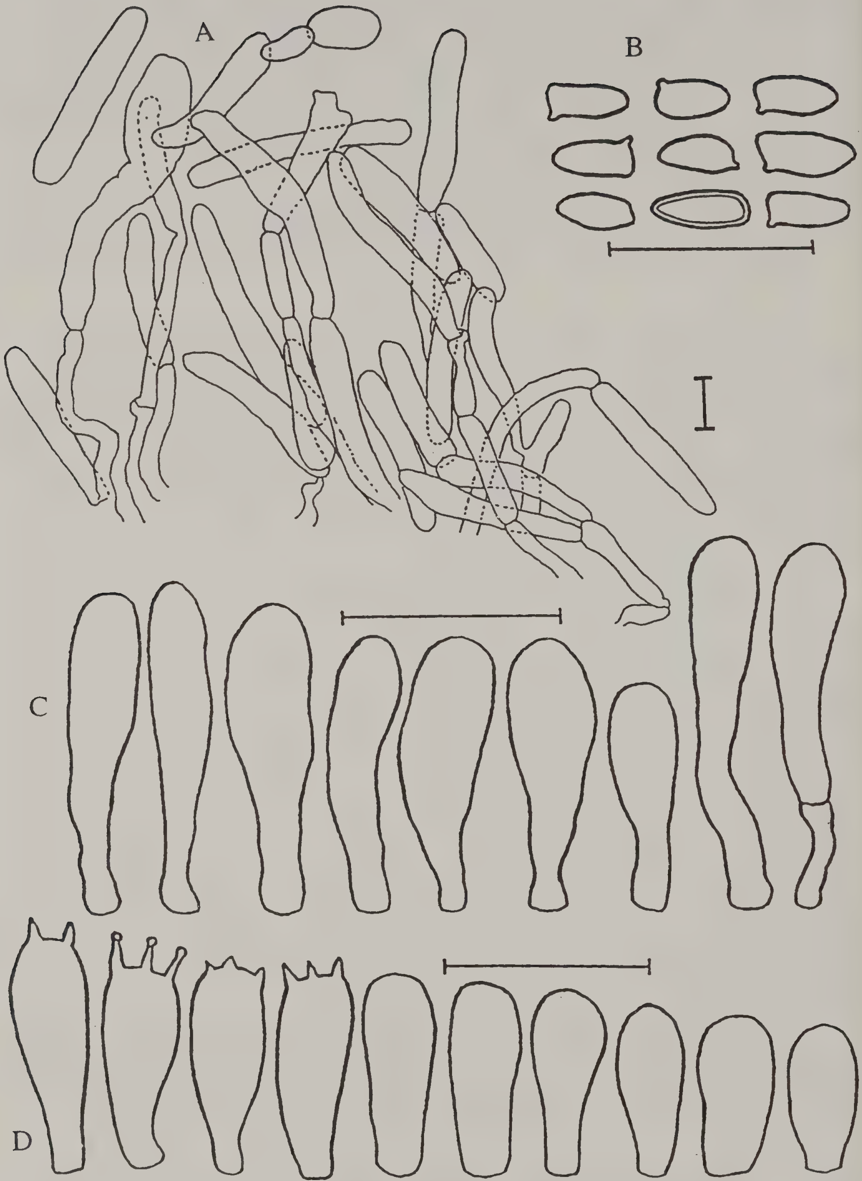

Fig. 2. *Lepiota truncatispora* Murrill. A. Pileipellis. B. Basidiospores. C. Cheilocystidia. D. Hymenial elements including basidia and basidioles. All illustrations FLAS F18395 (holotype). Scale bars = 20 μm.

lamellae white, fimbriate. **Stipe** features indeterminable, except for white, twine-like basal pseudorhizomorphs.

Micromorphological features: **Basidiospores** (Fig. 2B) 7.1-9.6 x 3.1-4.1 µm (Q = 2.26); wedge-shaped with truncate base and tapered apex, hilar appendix slightly conspicuous, wall smooth, thick (0.4 µm), germ pore none; hyaline in KOH, weakly dextrinoid (pale to medium rusty orange in Melzer's reagent), not or but feebly metachromatic. **Basidia** (Fig. 2D) 19-23.2 x 7.1-8.4 µm, clavate, tetrasterigmate; basidioles 14.7-20 x 6.4-7.6 µm, clavate; all hymenial elements hyaline in KOH, often with hyaline vesicles. **Cheilocystidia** (Fig. 2C) 21.3-53.5 x 5.7-8 µm, long-clavate, hyaline in KOH. **Pleurocystidia** lacking. **Pileipellis** (Fig. 2A) a trichoderm of branching, mostly erect to semi-erect, articulated to disarticulating hyphae, elements 20-110 x 10-25 µm, subcylindric to rarely ellipsoidal, walls smooth, thin, yellow in KOH and in Melzer's reagent, vacuolar pigment yellow to orange brown in KOH, deeper orange brown and with many vesicles or granules in Melzer's reagent. **Clamp connections** present in the pileipellis, and occasionally at the bases of cheilocystidia.

Collection studied: USA, FLORIDA. Alachua Co., Newnan's Lake, ca. 3 miles E of Gainesville, terrestrial in mixed woods, 15 Nov. 1938, *E. West* and *W. A. Murrill*, coll., *W. A. Murrill*, det., FLAS F18395 (holotype).

Comments. The critical characters of this species are not adequately understood, because the holotype is the only collection known and is poorly represented by fragments of 1-2 basidiomata. Murrill (1939) indicated the fresh collection had a somewhat unpleasant odor. He described the stipe as "equal, fibrillose, white, hollow, about 4 x 0.3 cm" and cited the annulus as "median, white, fixed, (and) slight or evanescent" (Murrill 1939: 370). Unfortunately, these features are not preserved for study in the herbarium collection. There is one other authentic collection labeled as this species (FLAS F47597), but it differs from the type in having cushion-like velar bracelets on the lower stipe, ellipsoidal rather than wedge-shaped spores, and a turf pileipellis of long, erect pilocystidia. These features, along with the presence of clamp connections, indicate a species in section *Ovisporae* (J.E. Lange) Kühner (Akers and Sundberg 1998).

Lepiota truncatispora is similar to *Lepiota ignicolor* Bres., except that the pileipellis in the latter species consists of long pilocystidia rather than articulated to disarticulating hyphae (Bon 1981; Enderle and Krieglsteiner 1989). It also resembles *Lepiota castanea* Quél., but that species reportedly lacks clamp connections (Smith *et al*. 1979). Following Bon's (1981) arrangement, *L. truncatispora* is here recognized in subsection *Stenosporinae* because of its basally truncate basidiospores and fibrillose pileipellis. Further collections of this elusive and presumably rare species would be invaluable to help clarify its features and taxonomic affinities.

Lepiota pseudoignicolor Dennis, Kew Bull. 15: 115 (1961) Fig. 3

Macromorphological features: **Pileus** 0.7-1.2 cm broad, plano-convex, umbo indistinct to low and moderately broad; cuticle fibrillose, bright rusty brick orange to ochraceous tan brown, disrupted concentrically into fine, minutely fibrillose squamules; lamellae cream. **Stipe** up to 3 x 0.1 cm, equal, pallid with rusty fibrillose squamules below annular zone; annulus not apparent.

Micromorphological features: **Basidiospores** (Fig. 3C) 8.4-12.1 x 3.5-5 μm (Q = 2.55); narrow, subtriangular to bullet-shaped with base truncate and spurred, hilar appendix fairly conspicuous, wall smooth to slightly rough, thick (0.5 μm), germ pore none; hyaline in KOH, weakly to moderately dextrinoid (light reddish brown in Melzer's reagent), not metachromatic. **Basidia** (Fig. 3F) 22-23 x 8.4-8.6 μm, clavate, tetrasterigmate; basidioles 11.6-21 x 5.5-8.5 μm; all hymenial cells hyaline in KOH. **Cheilocystidia** (Fig. 3G) 19-40 x 5.5-10 μm, abundant, clavate to slightly ventricose to subcylindric, walls smooth, thin-sturdy, hyaline in KOH. **Pleurocystidia** lacking. **Pileipellis** (Fig. 3D) a turf of long, thin, more or less erect pilocystidia, cylindric to subcylindric, up to 166 x 12.5 μm, arising from pedicels, walls smooth, yellow in KOH and in Melzer's reagent. **Clamp connections** present in pileus trama, and at bases of pilocystidia and cheilocystidia.

Collections studied: USA, FLORIDA. Alachua Co., University of Florida horticultural farm, 6 miles NW of Gainesville, 26 Aug. 1977, *W. J. Sundberg*, coll., *B. Akers*, det., SIUC WJS VIII-26-77-A5; Devil's Millhopper State Geological Site, 5 miles NW of Gainesville, 26 Aug. 1977, *W. J. Sundberg*, coll., *B. Akers*, det., SIUC WJS VIII-26-77-B5.

Comments. Descriptive notes accompanying the specimens studied here tentatively determined this collection as *Lepiota castanea*, but this identification is contradicted by the presence of abundant clamp connections. These collections match closely Dennis' (1961) concept of *L. pseudoignicolor*, based on his description and illustrations. This species is apparently a close relative of *Lepiota ignicolor*, a European species with numerous variants (Bon 1981). *L. pseudoignicolor* is placed here in subsection *Stenosporinae* because of its turf pileipellis of long, roughly cylindric pilocystidia. This type of pileipellis is very similar to that of *Lepiota clypeolaria* (Fr.) P. Kumm. (Akers and Sundberg 2000; Bon 1981). This species has not been previously reported from the USA.

DISCUSSION

The stenosporic basidiospores of the species discussed here are a distinctive and easily demonstrated character. They provide a useful distinguishing feature within *Lepiota* s. str., a genus otherwise noted for difficulty of species identification. Other features of taxonomic importance among these taxa include basidiospore dimensions, morphology of the

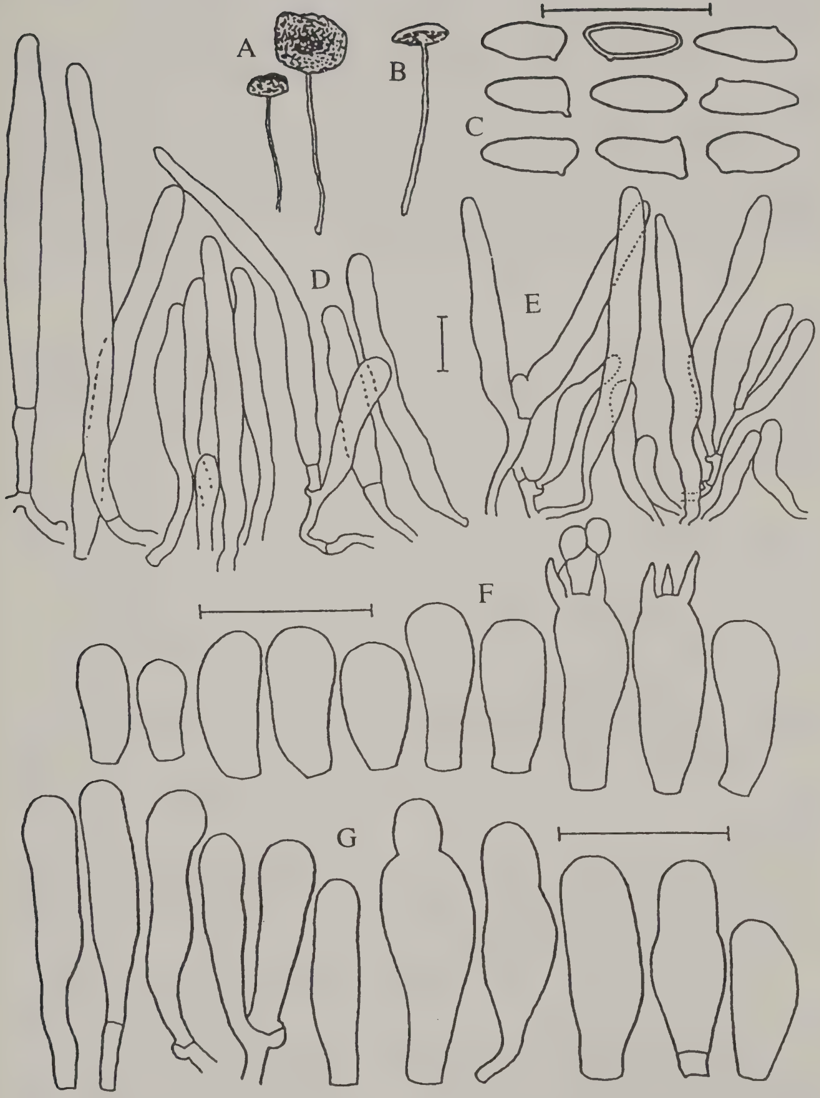

Fig. 3. *Lepiota pseudoignicolor* Dennis. A-B. Dried basidiomata, actual size. A. SIUC WJS VIII-26-77-A5. B. SIUC WJS VIII-26-77-B5. C. Basidiospores, SIUC WJS VIII-26-77-A5. D-E. Pileipellis. D. SIUC WJS VIII-26-77-B5. E. SIUC WJS-VIII-26-77-B5. F. Hymenial elements including basidia and basidioles, SIUC WJS VIII-26-77-A5. G. Cheilocystidia, SIUC WJS VIII-26-77-A5. Scale bars = 20 μm.

pileipellis and partial veil, and presence or absence of pleurocystidia and clamp connections.

While a few such species, most notably *Lepiota cristata*, have been widely collected and studied, many more remain poorly known in terms of their critical features and taxonomic affinities. Because understanding of the phylogeny and natural grouping of lepiotaceous taxa is currently undergoing changes, the approach taken here has been limited to subsectional classification, pending further investigations. Hopefully, the present report can serve as one small step toward a clearer understanding of the stenosporic species that occur in Florida.

ACKNOWLEDGMENTS

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FIVE NEW SPECIES OF BOLETACEAE FROM CHINA

MU ZANG

Cryptogamic Herbarium. Kunming Institute of Botany
Academia Sinica, Kunming 650204, China

TAI-HUI LI

Guangdong Institute of Microbiology
Guangzhou 510070, China

and

RONALD H. PETERSEN

Botany Department, University of Tennessee
Knoxville, Tennessee USA 37996

ABSTRACT

Five new species are proposed in the family Boletaceae: *Boletus sino-aurantiacus* Zang & Petersen, *B. hainanensis* Li & Zang, *Pulveroboletus reticulopileus* Zang & Petersen, *Sinoboletus maekawae* Zang & Petersen, and *Xerocomus sinensis* Li & Zang.

KEY WORDS. Biogeography, taxonomy.

Boletus sino-aurantiacus Zang & R.H. Petersen, *sp. nov.* (Fig. 1: 1-5).

Holotypus: CHINA, Yunnan, Simao (Szemao), Cai Yang He, 24.VI.2000, Zang no. 13486 (*in herb*. HKAS, no. 36065).

Pileus 2-5 cm latus, convexus demum planocavus, gelatinus et siccus, laevigatus, aurantiacus. Contextus 5-11 mm crassus, flavus, immutabilis. Tubuli 4-8 mm longi, flavi, adnati, sinuato-adnati. Pori simplices minuti ad medi-subrotundi vel angularis, 13-18 per cm. Hymenium flavidum. Stipes 5-8 X 0.6-1.2 cm, obclavatus, basim versus bulbosus, apice aurantiacus, roseo-pruinosis basi albus, haud reticulates. Basidiosporae 11.2-19.5 X 5-6.5 um, ellipsoideae. Basidia 20-26 X 15-18 um, obclavata, obovata, 4-sporigera. Pleurocystidia 36-40 X 26-30 um, late ovata. Cheilocystidia 38-45 X 18-28 um, fusiformia. Tramae tubi paralleloneurae. Mycelio albo.

Habitus: In Fagaceae forest, especially usually under *Castanopsis ferox* (Roxb.) Spach.

Pileus (Fig. 1: 1) 2-5 cm broad, convex expanding to plane; surface gelatinized when young, dry when mature, smooth, between yellow and scarlet; context 5-11 mm thick, yellow to pale yellow, unchanging on exposure. Hymenophore yellow; tubes 4-8 mm long, yellow, broadly adnate, subsinuate; trama (Fig. 1: 3) parallel; pores simple, small to medium-sized (13-18 per cm), almost circular or with prominent angles. . Stipe 5-8 X 0.6-1.2 cm, obclavate to equal, bulbous at base, golden at apex, pale golden at base, not reticulate. Basidiospores (Fig. 1: 2) 11.2-19.5 X 5-6.5 um, elongate-ellipsoid to ellipsoid or mango-shaped. Basidia (Fig. 1: 2) 20-26 X 15-18 um, obclavate, obovate, 4-spored. Pleurocystidia (Fig. 1: 4) 36-40 X 26-30 um, broadly ovate. Cheilocystidia (Fig. 1: 5) 38-45 X 18-28 um, fusiform. Mycelium whitish.

Additional specimens examined: Yunnan, Simao (Szemao), Cai Yang He, 1680 m alt, fagaceous forest, 24.VI.2000, Zang no. 13489 (HKAS 36294); Simao, Cai Yang He Tian Bi, 24.VI.2000, 1550 m alt, under *Castanoposis ferox*, Zang no. 13508 (HKAS no. 36065); same location, 20.VI.2000, Zang no. 13418 (HKAS no. 36112); Cai Yang He, Da Ming Cao, 2.VII.2000, 1570 m alt, Zang no. 13549 (HKAS 36437).

Etymology: Latin; *sino* = Chinese; *aurantiacus* = orange, in reference to the orange color of pileus and stipe.

Commentary: The new species can be placed in *Boletus* sect. *Luridi* (Zang, 1999). The fungus is distinguished by broadly ovate cheilocystidia, jelly-like pileus surface when young, and large basidiospores.

Boletus hainanensis T.H. Li & M. Zang, *sp. nov*. (Fig. 1: 6-10)

Basionym: *Boletus erythropus* f. *hainanensis* T.H. Li, *nomen nudum*. 1997. pp. 294-295, *in*: Bi, Z-S. T-H.Li, W-M. Zhang, and B. Song (Eds.), A Preliminary Agaric Flora of Hainan Province.

Holotypus: CHINA, Hainan, Chang Jiang Co., Ba Wang Ling, 28.VII.1987, coll. Q. Chen & T.H. Li no. 16472 (HMIGD).

Pileus 3.5-5 cm latus, convexus demum plano-cavus, siccus, atropurpureus, atrosanguineus, purpureo-brunneus, tomentosus vel laevigatus. Contextus 1-3 cm crassus, flavus, albo-flavus, caerulescens. Hymenium sanguineum, atrosanguineum. Tubuli 4-6 mm longi, flavi, adnati. Pori 2-3 per mm, rotundi vel angulares. Stipes 5-7 X 0.5-1 cm, clavatus, basim versus bulbosus, rubidus, basi albus, haud reticulates, apice striatus. Basidiosporae 11-19 X 4-5.2 um, ellipsoideae, flavesco-hyalinae, laevis. Basidia 19-21 X 10-16 um, ovata, 4-sporigera. Pleurocystidia 20-30 X 10-16 um, late fusiformia. Cheilocystidia 20-60 x 10-16 um, fusiformia. Tramae tubi paralleloneurae.

Habitat: In forests of *Castanopsis hainanensis* Merr. and *C. tonkinensis* Seem.

Pileus (Fig. 1: 6) 3-5 cm broad, convex to plano-convex, dry, dark purple, dark blood-red, purple-brown, tomentose to smooth; context 1-3 cm thick, yellowish, whitish yellow, changing blue when cut. Tubes 4-6 mm long, yellow, adnate; hymenium scarlet to deep scarlet; pores 2-3 per mm, rounded to angled; tube trama

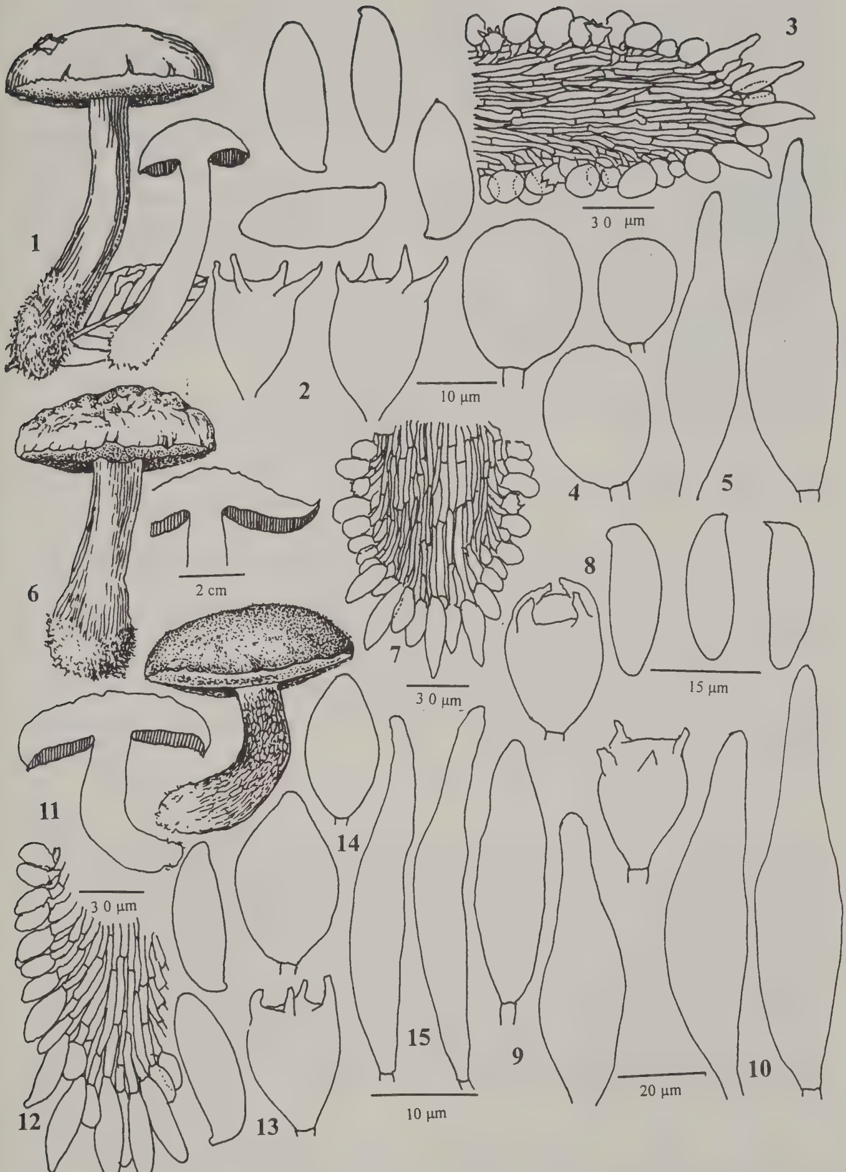
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Fig 1. 1-15. Boletales from China. 1-5. *Boletus sino-aurantiacus*. 1. Basidiomata. 2. Basidia and basidiospores. 3. Tube hyphal arrangement. 4. Pleurocystidia. 5. Cheilocystidia. 6-10. *Boletus hainanensis*. 6. Basidiomata. 7. Tube hyphal arrangement. 8. Basidium and basidiospores. 9. Pleurocystidia. 10. Cheilocystidia. 11-15. *Xerocomus sinensis*. 11. Basidiomata. 12. Tube hyphal arrangement. 13. Basidium and basidiospores. 14. Pleurocystidia. 15. Cheilocystidia.

(Fig. 1: 7) parallel. Stipe 5-7 X 0.5-1 cm, clavate to equal, ruby red apically, not reticulate but striate apically; base bulbous, whitish. Basidiospores (Fig. 1: 8) 11-19 X 4-5.2 um, ellipsoid, hyaline to pale yellow, smooth. Basidia (Fig. 1: 8) 19-21 X 10-16 um, ovate, 4-spores. Pleurocystidia (Fig. 1: 9) 20-30 X 10-16 um, broadly fusiform. Cheilocystidia (Fig. 1: 10) 20-60 X 10-16 um, fusiform.

Commentary: Pore mouths are more or less uniformly red, similar to those of *B. erythropus* Fr., but the fungus is characterized by the dark purplish pileus, not blackish brown and basidiospores are longer. Basidiomata are found under *Castanopsis* forest, not under *Picea* or *Tsuga* forests.

The basionym was previously proposed at form rank, but lacked a Latin diagnosis. With the Latin diagnosis above, requirements for valid publication have been met, and the epithet is proposed here at species rank.

Pulveroboletus reticulopileus Zang & R.H. Petersen, sp. nov. (Fig 2: 7-10)

Holotypus: CHINA, Yunnan, Dali, Dian Cang Mts., Sha Si Pavilion, 3420 m alt., under *Abies georgei*, 7.IX.2000, coll. Zang, no. 13697 (HKAS no. 36696).

Pileus 4-5.5 cm latus, convexus demum plano-convexus, siccus, rugulosus, reticulato-venosus, flavus, aureus. Contextus 3-7 mm crassus, flavus, immutabilis. Tubuli 5-9 mm longi, grisi, purpurati, brunneoli. Pori simplices, longiusculi vel angulares, 7-10 per cm. Hymenium cano-purpuratum. membranifer. Stipes 5-8 X 1-1.5 cm, obclavatus, basim versus bulbosus, aurantiacus, haud reticulates. Basidiosporae 9-17 X 5-6.5 um, ellipsoideae, late ovatae. Basidia 20-25 X 15-20 um, obovata, 4-sporigera. Pleuro- et cheilocystidia 30-50 X 8-15 µm, fusiformia. Tramae tubi paralleloneurae. Mycelio flavo.

Habitat: under *Abies georgei* Orr.

Pileus (Fig. 2: 7) 4-5.5 cm broad, convex when young, expanding to plane; surface dry, somewhat wrinkled, net-veined, yellow to golden yellow; context 3-7 mm thick, yellow to pale yellow, unchanging on exposure. Tubes 5-9 mm long, grayish, purplish, brownish; pores simple, moderately radial or with prominent angles, 7-10 per cm; tube trama (Fig. 2: 10) parallel; hymenium grayish, purplish, covered with membranous veil when young. Stipe 5-8 X 1-1.5 cm, clavate, equal, golden color, not reticulate; base bulbous; partial veil membranous, brilliant yellow. Basidiospores (Fig. 2: 8) 9-17 X 5-6.5 um, ellipsoid to narrowly ovate. Basidia (Fig. 2: 8) 20-25 X 12-15 um, obovate to fusiform, 4-spored. Pleurocystidia and cheilocystidia (Fig. 2: 9) 30-50 X 5-15 um, fusiform. Mycelium yellowish.

Etymology: *reticulo* = forming a network; *pileus* = basidioma cap, in reference to the net-veined surface of the cap.

Commentary: The brilliant yellow color of the basidiome, with yellow pulverulence from a dry partial veil, seem similar to *P. ravenelii* (B. & C) Murrill, but the tube trama hyphae are parallel, not divergent from a central strand (Smith and Thiers, 1971). *Pulveroboletus ravenelii* also exhibits different colored, cyanescent hymenophore and

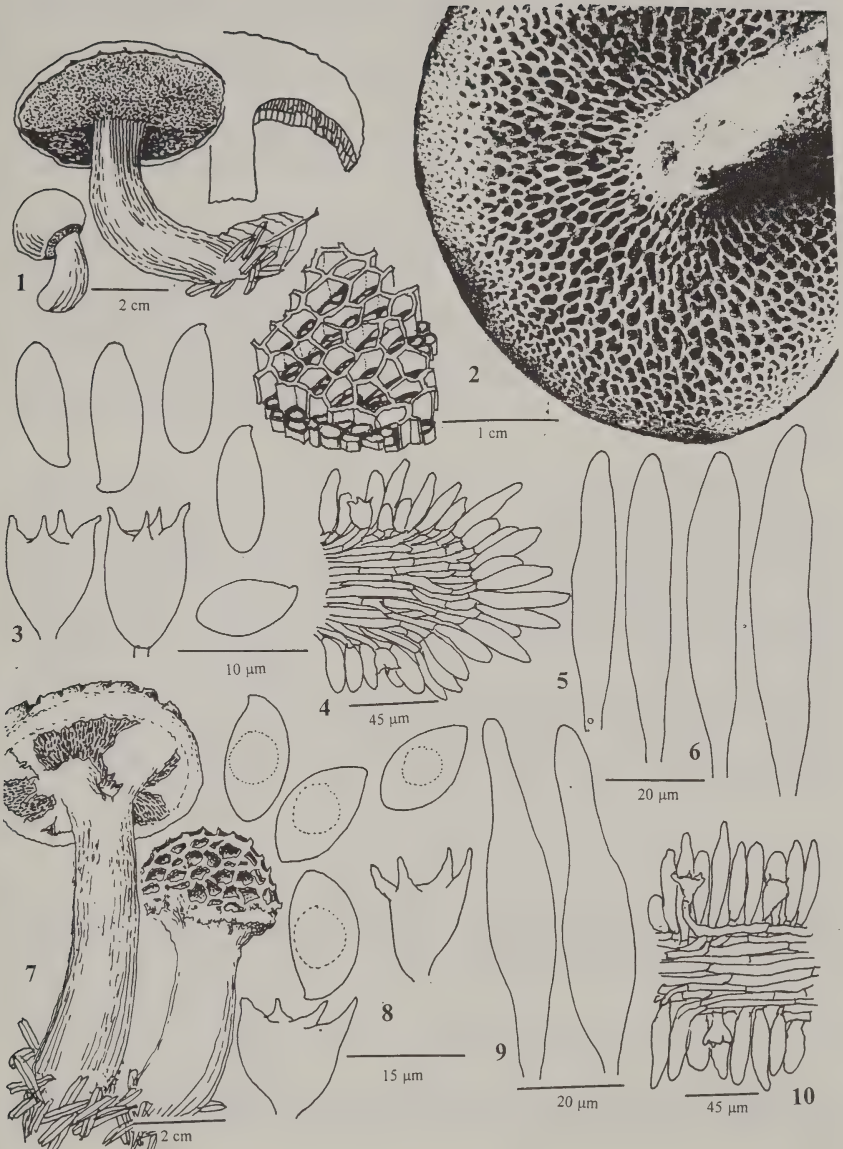
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Fig 2. 1-10. Boletales from China. 1-6. *Sinoboletus maekawae*. 1. Basidiomata. 2. Stratose hymenium. 3. Basidia and basidiospores. 4. Tube hyphal arrangement. 5. Pleurocystidia. 6. Cheilocystidia. 7-10. *Pulveroboletus reticulopileus*. 7. Basidiomata. 8. Basidium and basidiospores. 9. Cystidia. 10. Tube hyphal arrangement.

flesh. *Pulveroboletus reticulopileus* is further distinguished by the net-veined pileus surface.

Sinoboletus maekawae Zang & R.H. Petersen, sp. nov. (Fig. 2: 1-6)

Holotypus: CHINA, Yunnan, Dali, Dian Cang Mts., Sha Si Pavilion, 3420 m alt., under *Abies georgei* and *Lithocarpus dealbatus* , 7.IX.2000, coll. Maekawa & Zang, Zang no. 13698 (HKAS no. 36698).

Pileus 2.5-5 cm latus, convexus demum plano-convexus, siccus, atro-brunneus, atro-fuscus. Contextus 0.5-1 cm crassus, flavus, immutabilus. Hymenium aureum. Tubi bistrati, connexi, superiori 0.1-0.3 mm longi, 0.1-0.2 mm crassi, interiori 2-4 mm longi, 0.1-0.3 mm crassi, adnati, sinuato-adnati, decurrenti. Pori angulares vel irregulares, 3-7 per cm. Stipes 4-5 X 0.6-1.1 cm crassus, obclavatus, luteus, citrinus. Basidiosporae 6.5-13 X 4-5 um, ellipsoideae, laevis, flavo-hyalinae. Pleurocystidia 35-40 X 10.4-15 um, clavata. Cheilocystidia 37-45 X 7.8-10 um, perangusto clavata. Tramae tubi paralleloneurae.

Habitat: Under *Abies georgei* and *Lithocarpus dealbatus* (Hook. *f. et* Thoms) Rehd..

Pileus (Fig. 2: 1) 2.5-5 cm broad, convex when young, expanding to plane; surface dry, dark brown to dark sordid brown; context 0.5-1 cm thick, yellow, unchanging on exposure. Hymenophore (Fig. 2: 2) golden yellow to bright yellow, adnate to sinuate-adnate, decurrent, boletinoid and compound; tubes (Fig. 2: 2) with cross-veins produced in two definite layers; superior tubes 0.1-0.3 mm long, 0.1-0.2 mm diam; interior tubes 2-4 mm long, 0.1-0.2 mm diam, adnate to faintly sinuate; pores angular or irregular, large, 3-7 per cm; tube trama (Fig. 2: 4) parallel. Stipe 4-5 X 0.6-1 cm, obclavate, yellow, lemon yellow, dry, not reticulate but striate at apex. Basidiospores (Fig. 2: 3) 6.5-13 X 3-5 um, ellipsoid, smooth, hyaline to pale yellow microscopically. Basidia (Fig. 2: 3) 15-20 X 7.8-10 um, narrowly clavate.

Etymology: *maekawa* = in honor of mycologist Dr. Nitaro Maeckawa.

Commentary: *Sinoboletus maekawae* is characterized by the dark somber brown or sordid brown pileus. Although similar to that of *S. magnisporus* Zang & Chen (Zang and Chen, 1998), basidiospores of *S. magnisporus* are larger (15.6-20.8 X 6.5-7.8 um), and cheilocystidia are broadly fusiform.

Xerocomus sinensis T.H. Li & M. Zang, *sp. nov.* (Fig. 1: 11-15)

Basionym: *Boletus luridus* f. *sinensis* (T.H. Li) *nomen nudum, in* Z-S. Bi, T-H. Li, W-M. Zhang, and B. Song, Eds. 1997. A Preliminary Agaric Flora of Hainan Province. pp. 294-295.

Holotypus: CHINA, Hainan, Le Dong County, Jian Feng Ling, Tian-Chi, 2.X.1987, coll. T.H. Li, no. 13070 (HMIGD).

Pileus 4-13 cm latus, convexus, siccus, tomentosus, flavo-ochraceus, fuscus vel olivaceus, griseus. Contextus 1-2 cm crassus, flavus, caerulescens. Hymenio rubro-brunneum, Tubuli 2.5-5 mm longi, sinuolati. Pori simplices subrotundi, 20-26 per cm.

Stipes 4-12 X 1-2.5 cm, obclavatus, basim versus bulbosus, siccus, cerasinus, reticulates. Basidiosporae 13-19 X 5-6.5 um, ellipsoideae. Basidia 20-35 X 15-25 um, brevi-clavata. Sterigmata 4. Pleurocystidia 20-40 X 10-16 um, brevi-fusiformia. Cheilocystidia 30-50 X 10-15 um, fusiformia. Tramae tubi divaricatae.

Habitat: In Fagaceae forest, probably under *Cyclobalanopsis patelliformis* (Chun) Chun.

Pileus (Fig. 1: 11) 4-13 cm broad, convex; surface dry, tomentose, ochre yellow, brown, olive green to olive gray; context 1-2 cm thick, yellowish, changing blue when cut. Hymenophore red-brown; tubes 2.5-5 mm long, faintly sinuate; trama (Fig. 1: 12) divergent; pores simple, subrounded, 20-26 per cm. Stipe 4-12 X 1-2.5 cm, obclavatus to equal, dry, cherry red, reticulate; base bulbous. Basidiospores (Fig. 1: 13) 13-19 X 5-6.5 um, ellipsoid. Basidia (Fig. 1: 13) 20-35 X 15-25 um, broadly clavate, 4-spored. Pleurocystidia (Fig. 1: 14) 20-40 X 10-16 um, broadly fusiform. Cheilocystidia (Fig. 1: 15) 30-50 X 10-15 um, fusiform.

Etymology: *sinensis* = referring to China.

Commentary: Basidiomata of *X. sinensis* are characterized by the ochre yellow cap and cherry red stipe. Basidiospores are larger than those of *Boletus luridus* Schaeff.: Fr., and pleurocystidia are more broadly fusiform.

The species epithet was previously published as a *nomen nudum*. Here the requirements for valid publication are met, and the epithet is proposed at species rank.

ACKNOWLEDGEMENTS

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TAXONOMY OF GOLOVINOMYCES ON CUCURBITS

DEMETRIOS J. VAKALOUNAKIS AND EFROSINI KLIRONOMOU

N.AG.RE.F., Plant Protection Institute, P.O. Box 2228, 711 03 Heraklio,
Crete, Greece
vakalounakis@imbb.forth.gr

Keywords: *Golovinomyces cucurbitacearum*, powdery mildew

Powdery mildews are important diseases of cucurbits in Greece and many other countries (Vakalounakis 1988). The pathogens recorded include: *Sphaerotheca fuliginea* (Schltdl.: Fr.) Pollacci, *Erysiphe cichoracearum* DC. s.l. (≡ *Golovinomyces cichoracearum* (DC.) V.P. Gelyuta), *E. communis* (Wallr.) Link, *E. cucurbitacearum* R.Y. Zheng & G.Q. Chen, *E. polygoni* DC., *E. polyphaga* Hammarl., *Leveillula taurica* (Lév.) M.A. Arnaud as well as *Oidium* spp. (Ballantyne 1974).

Braun (1987) referred polyphagus races of *E. cichoracearum* to *E. orontii* Castagne emend. U. Braun and confined the name *E. cichoracearum* to powdery mildews on hosts of the family Compositae. *E. cucurbitacearum* was reduced to synonymy with *E. orontii*, since the description of distinctly narrower conidia in *E. cucurbitacearum* was considered to be based on dry shriveled herbarium specimens (U. Braun, in litt.).

Vakalounakis et al. (1994) and Vakalounakis and Klironomou (1995) carried out comprehensive biological, morphological and host range examinations of cucurbit powdery mildews in Greece. They studied 477 fresh samples, including 24 isolates belonging to *Erysiphe* sect. *Golovinomyces* characterized by narrow conidia [12-18 µm wide] similar to those given by other researchers (Nagy 1970, Lebeda 1983) for *G. orontii* on cucurbits (as *E. cichoracearum*), although these records do not agree with the true *G. orontii* which possesses wider conidia [15-23 µm] (Braun 1987, 1995). However, the conidial dimensions of these isolates agree very well with those of *E. cucurbitacearum* [12-15 µm wide] (Zheng and Chen 1981). Vakalounakis et al. (1994) and Vakalounakis and Klironomou (1995) suggested that the inclusion of *E. cucurbitacearum* in *G. orontii* (as *E. orontii*) by Braun (1987,

1995) is not correct, which was confirmed by U. Braun (in litt.). Hammarlund (1945) and Blumer (1952) carried out comprehensive inoculation experiments with *E. polyphaga* (= *E. orontii*) and demonstrated that this species is able to infect various cucurbits. Hence, there are two species of *Erysiphe* sect. *Golovinomyces* on cucurbitaceous hosts worldwide, viz., *E. orontii* (= *E. cichoracearum* s.l.) with wider conidia and *E. cucurbitacearum* with narrower conidia. Ascomata are rarely formed in *E. orontii*, so that the differentiation between the two species based on the teleomorph is not yet known.

Braun (1999), based on new data obtained by means of SEM (Cook et al. 1997) and molecular analyses (Takamatsu et al. 1998, Saenz and Taylor 1999), divided *Erysiphe* s.l. into three genera, viz., *Erysiphe* emend. (incl. *Erysiphe* DC. sect. *Erysiphe, Microsphaera* Lév. and *Uncinula* Lév.), *Golovinomyces* (U. Braun) V.P. Gelyuta (≡ *Erysiphe* sect. *Golovinomyces* U. Braun) and *Neoerysiphe* U. Braun stat. et nom. nov. (≡ *Erysiphe* sect. *Galeopsidis* U. Braun). Following the new taxonomy of Braun (1999), *Golovinomyces orontii* (Castagne) V.P. Gelyuta is the correct name for *E. orontii*, and *Erysiphe cucurbitacearum* has to assigned to *Golovinomyces*:

Golovinomyces cucurbitacearum (R.Y. Zheng & G.Q. Chen) D.J. Vakalounakis & E. Klironomou **comb. nov.**

Basionym: *Erysiphe cucurbitacearum* R.Y. Zheng & G.Q. Chen, *Sydowia* 34: 258 (1981).

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CYATHUS (GASTEROMYCETES) IN AREAS OF THE BRAZILIAN CERRADO REGION, SÃO PAULO STATE

Iuri Goulart Baseia* and Adauto Ivo Milanez
Instituto de Botânica, Seção de Micologia e Liquenologia
Caixa Postal 4005, 01061-970, São Paulo (SP), Brazil
*ibaseia@bol.com.br

Abstract

A survey on *Cyathus* (Gasteromycetes, Nidulariales), occurring on cerrado region in State of São Paulo (Brazil), was undertaken from November/1998 to April/2000, mostly in the rainy seasons. Several specimens belonging to nine species were identified: *Cyathus berkeleyanus*, *C. limbatus*, *C. montagnei*, *C. olla*, *C. pallidus*, *C. poeppigii*, *C. stercoreus*, *C. striatus* and *C. triplex*. *C. olla* and *C. triplex*, represent first records from Brazil. Descriptions of the macro and microscopic features from these *Cyathus* species are given including taxonomic and some ecological data. A key to the species is also presented.

Keywords: Nidulariaceae, taxonomy, lignicolous fungi, first records.

Introduction

The genus *Cyathus* Haller: Pers. comprises 44 species with worldwide distribution (Hawksworth et al., 1995). Basidiomata are characterized by a peridium bell-shaped, obconical or infundibuliform, three-layered peridial wall, a well-defined epiphragm and a complex cord-like funiculus (Bottomley, 1948). Many of the species have a wide geographic distribution, but a few are limited in their range (Brodie, 1984).

Till now, six *Cyathus* species, *C. berkeleyanus* (Tul. & C. Tul.) Lloyd, *C. limbatus* Tul. & C. Tul., *C. montagnei* Tul. & C. Tul., *C. poeppigii* Tul. & C. Tul., *C. stercoreus* (Schwein.: De Toni) De Toni, *C. striatus* (Huds.: Pers.) Pers. and *C. vernicosus* (Bull.) DC., were recorded from Brazil by Bononi (1984), Bononi et al. (1981, 1984) and Rick (1961). As a striking importance of some of these species we can mention their property in the production of antibiotic substances (Allbutt et al., 1971; Brodie, 1984; Wilkins, 1954). In nature, they are efficient biological agents of recycling organic material. This paper reports on results for a survey of *Cyathus* species from the "cerrado" areas in the State of São Paulo, our aim being to give an improved knowledge about this group.

According to Greuter et al. (1993) the name *Cyathus* is attributable to Persoon, but as indicated by Bottomley (1948) and Brodie (1975) the name dates from much earlier. Following the changes to the ICBN enacted in 1981 the appropriate author citation indicating the sanctioned status of this name should be *Cyathus* Haller: Pers. (Coetzee et al., 1997)

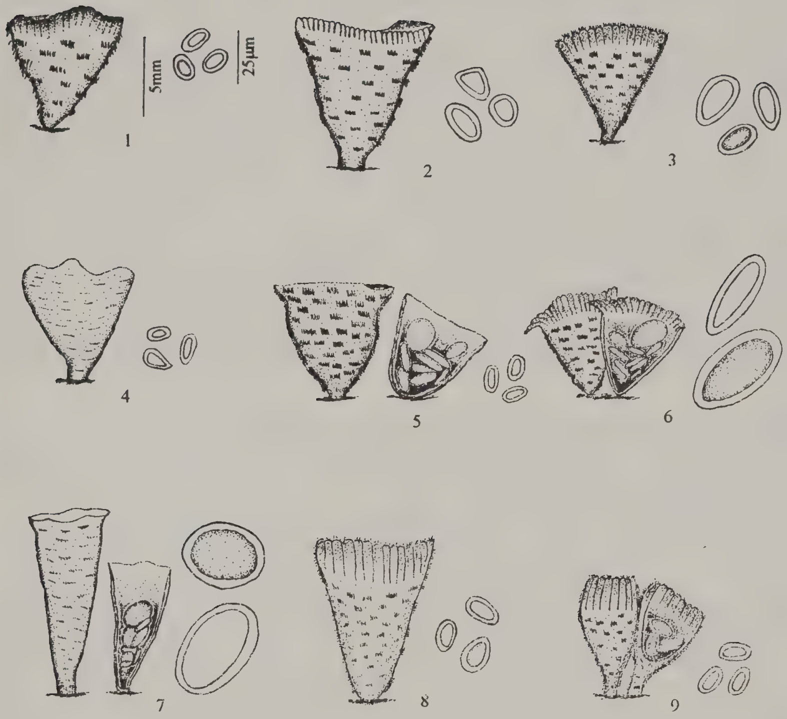
Materials and Methods

Basidiomata of *Cyathus* species were collected from November/1998 to August/2000 (mostly in the rainy seasons), in the Estação Ecológica de Jataí, located in an area of 4.532 ha, at 21°33’-21°37’S and 48°45’-48°51’W; Estação Ecológica de Itirapina, located in an area of 2.300 ha, at 22°28’-22°30S and 48°17’-48°19’W and Reserva Biológica de Moji Guaçu, located in an area of 343 ha, at 22^{0}15’-22^{0}16’S and 47^{0}08’-47^0-12’W, all in State of São Paulo. Climatic conditions are the AW type according to Köppen System (Eiten, 1993). During the fieldtrips the material was randomly collected along the existing trails or new ones with aim to cover the physiognomic types of the “cerrado” vegetation.

Fresh and dried materials were mounted for examination in light microscopy by removing small sections of the peridium and peridiolum from the basidiocarp, soaking them in Melzer’s reagent with 5% KOH (Domínguez de Toledo, 1993). Permanent slides were made using PVL resin (alcohol polyvinilic and lactophenol), according to Trappe and Schenck (1982). Colour terms in parenthesis are those of Kornerup and Wanscher (1978). The material was preserved at the Herbario do Estado Maria Eneyda P. K. Fidalgo (SP), abbreviated by acronyms according to the Index Herbariorum (Holmgren et al., 1990).

Key to the species

1 Tunic present 2
1’ Tunic absent 3
2 Peridioles large (2-2.5 mm diam.) 4
2’ Peridioles small (up to 2 mm diam.) 5
3 Basidiospores large (20-30 x 18-30 µm) 6
3’ Basidiospores small (14-17 x 10-12 µm) 7
4 Basidiospores 15-25 x 10-20 µm, outer and inner surfaces of the peridium plicate, mouth fibrilose .... *Cyathus montagnei*
4’ Basidiospores 6-13 x 6-8 µm, outer and inner surfaces of the peridium smooth, mouth glabrous .... *C. olla*
5 Basidiomata large (10-12 high x 7-10 mm wide), yellowish-brown (5D4), strongly hirsute, mouth with short setae or smooth .... *C. sriatus*
5’ Basidiomata medium (7-8 high x 6-7 mm wide), yellowish-brown (5E5), hirsute to shaggy in age, mouth glabrous and finely sulcate .... *C. berkeleyanus*
5’’ Basidiomata small (4-5 high x 4-5 mm wide), light brown (5D4), strigose to glabrous in age, mouth smooth .... *C. pallidus*
6 Basidiomata short (6-8 high x 4-6 mm wide), yellowish-brown (5F5), outer and inner surface plicate .... *C. poeppigii*
6’ Basidiomata tall (10-13 high x 4-5 mm wide), light brown (5D6), outer and inner surfaces smooth .... *C. stercoreus*
7 Basidiomata large (10-12 high x 7-8 mm wide), mouth glabrous strongly fluted .... *C. limbatus*
7’ Basidiomata small (6-8 high x 3-5 mm wide), mouth fimbriate .... *C. triplex*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Figs. 1-9. Basidiomata and basidiospores: 1. *Cyathus berkeleyanus*, 2. *C. limbatus*, 3. *C. montagnei*, 4. *C. olla*, 5. *C. pallidus*, 6. *C. poeppigii*, 7. *C. stercoreus*, 8. *C. striatus*, 9. *C. triplex*.

Results

Cyathus berkeleyanus (Tul. & C. Tul.) Lloyd, Myc. Writ. 2, Nidulariaceae, 19, 1906. Basyonym: *Cyathus microsporus* var. *berkeleyanus* Tul. & C. Tul., Ann. Sci Nat. III, 1: 74, 1844.
Fig. 1

Peridium obconical, 7-8 mm high, 6-7 mm wide at the mouth, attenuated towards a broad base, attached to the substratum by a yellowish-brown (5F4) cushion-like pad; outer surface yellowish-brown (5E5), hirsute to shaggy, becoming glabrous in age; inner surface greyish-yellow (4B3), plicate, shiny; mouth finely sulcate; peridioles lenticular, 1.5-2 mm diam., dark grey (3F2), cortex composed by a single layer of hyphae, tunic present; basidiospores ellipsoid, 8-9 x 4-5 µm, thick-walled, smooth, almost hyaline.

Material examined: BRAZIL, São Paulo: Município de Itirapina, Estação Ecológica de Itirapina, 08/VII/1999, I. G. Baseia 414, SP 307496; Município de Luís Antônio, Estação Ecológica de Jataí, 23/II/2000, I. G. Baseia 440, SP 307497.

Additional material examined (donated to SP Herbarium): BRAZIL, São Paulo: Município de São Paulo, Parque do Estado, 15/VII/1960, det. M. H. Homrich, SP 50495.

Habitat: Solitary on decaying wood or leaves in gallery forest.

Distribution: Jamaica (White, 1902), Brazil (Lloyd, 1906; Bononi et al., 1984), South Africa (Bottomley, 1948), West Indies (Brodie and Dennis, 1954), China (Liu, 1984), Mexico (Léon-Gómez and Pérez-Silva, 1988).

Remarks: Macroscopically, *Cyathus berkeleyanus* resemble small specimens of *C. limbatus* or *C. poeppigii* from which they differ markedly by the presence of a tunic and in microscopic features. From other fluted species of *Cyathus*, *C. berkeleyanus* may be distinguished by its very small subglobose basidiospores (Brodie and Dennis, 1954). The taxonomic characteristics of the material are close to those of the additional material examined and the literature. According to Brodie (1975), the Tulasne brothers considered it as a variety of *C. microsporus*, naming it *Cyathus microsporus* var. *berkeleyanus* Tul. & C. Tul. However, when treated as a separate species, the correct author citation should be *Cyathus berkeleyanus* (Tul. & C. Tul.) Lloyd.

Cyathus limbatus Tul. & C. Tul., Ann. Sci. Nat. III, 1: 78, 1844.
Fig. 2

Peridium campanulate, 10-12 mm high, 7-8 mm wide at the mouth, attached to the substratum by a yellowish-brown (5D5) mycelium; outer surface yellowish-brown (5D5), plicate, hirsute; inner surface yellowish-brown (5D6) to dark brown (6F5), plicate; mouth fluted; peridioles lenticular, 1.8-2 mm diam., dark brown (5F4) to black, with two-layered cortex, tunic absent; basidiospores ellipsoid to oval, 15-20 x 10-12 µm, thick-walled, smooth, hyaline.

Material examined: BRAZIL, São Paulo: Município de Itirapina, Estação Ecológica de Itirapina, 19/III/1999, I. G. Baseia 376, SP 307506; Município de Moji Guaçu, Reserva Biológica de Moji Guaçu, 10/VII/1999, I. G. Baseia 416, SP 307502; Município de Luís Antônio, Estação Ecológica de Jataí, 27/03/2000, I. G. Baseia 498, SP 307507.

Habitat: Solitary or in groups on wood debris, in "cerradão".

Distribution: British Guyana (Tulasne and Tulasne, 1844), Cuba (White, 1902), South Africa (Bottomley, 1948), West Indies (Brodie and Dennis, 1954), West Tropical Africa (Dring, 1964), China (Liu, 1984), Mexico (Léon-Gómez and Pérez-Silva, 1988).
Remarks: *C. limbatus* is characterized by basidiomata large and robust, outer and inner surfaces fluted, peridioles deep brown to black, and shiny (Brodie, 1975). It differs from *C. poeppigii*, which resembles in a general way, in its usually bigger size and smaller basidiospores. Stafleu and Cowan (1986) pointed out that L. R. Tulasne's brother, Charles, co-authored the work on the Nidulariales, and consequently, names published therein should be attributed to both brothers. The correct author citation for this name therefore is *Cyathus limbatus* Tul. & C. Tul. (Coetzee et al., 1997).

Cyathus montagnei Tul. & C. Tul., Ann. Sci. Nat. 1: 70, 1844.
Fig. 3
Peridium obconical, 7-8 mm high, 6-7 mm wide at the mouth, attenuated towards a broad base, attached to the substratum by a dark brown (6F6) mycelium; outer surface dark brown (6F2), delicately plicate, hirsute to strigose becoming glabrous in age; inner surface brownish-grey (5F2), strongly plicate in upper part; mouth fibrilose; peridioles lenticular, 2-2.5 mm diam., dark brown (5F6) to black, cortex composed of a single layer of hyphae, tunic present; basidiospores subglobose to broad-elliptic, 15-25 x 10-20 µm, thick-walled, smooth, hyaline.
Material examined: BRAZIL, São Paulo: Município de Luís Antônio, Estação Ecológica de Jataí, 07/III/2000, I. G. Baseia 499, SP 307501.
Additional material examined (donated to SP Herbarium): BRAZIL, São Paulo: Município de São Paulo, Serra da Cantareira, 1900, coll. A. Puttemans, det. P. Hennings, SP 141777; Rio Grande do Sul: Município de São Leopoldo, 1904, det. J. Rick, SP 33984.
Habitat: In groups on decaying wood in gallery forest, rare.
Distribution: Brazil (Hennings, 1904; Lloyd, 1906; Rick, 1961), Cuba (White, 1902), South Africa (Bottomley, 1948), Congo (Dissing and Lange, 1962), China (Liu, 1984), Mexico (Léon-Gómez and Pérez-Silva, 1988), Tanzania (Calonge et al., 1997).
Remarks: *C. montagnei* recalls *C. berkeleyanus* but it is segregated due to its large peridioles and basidiospores. *C. montagnei* has a widespread distribution in tropicals zones, mainly Central America (Brodie, 1975). Few specimens are deposited in the Brazilian Herbaria and are insufficiently documented. In the area studied it seems to be rather rare, only a single collection being gathered.

Cyathus olla (Batsch: Pers.) Pers., Syn. Meth. Fung., 237, 1801.
Basyonym: *Peziza olla* Batsch, Elench. Fung. 127, 1783.
Fig. 4
Peridium obconical, 8-11 mm high, 5-6 mm wide at the mouth, tapering to the substipitate base; outer surface yellowish-brown (5D3), smooth, hirsute to tomentose consisting of fine appresed hyphae; inner surface brownish-grey (5F1) to dark brown (6F5), smooth; mouth smooth, edge incurved; peridioles lenticular, 2-2.5 mm diam., dark brown (6F6), cortex composed of a single layer of hyphae, covered with a thin tunic yellowish-brown (5D4); basidiospores globose to ellipsoid, 6-13 x 6-8 µm, thick-walled, smooth, almost hyaline.
Material examined: BRAZIL, São Paulo: Município de Luís Antônio, Estação Ecológica de Jataí, 27/III/2000, I. G. Baseia 494, SP 307494.

Additional material examined (donated to SP Herbarium): BRAZIL, Maranhão: Município de Lôreto, 1965, det. C. T. Rogerson, SP 94492.
Habitat: In groups on decaying wood in "cerradão", rare.
Distribution: South Africa (Bottomley, 1948), Norway (Eckblad, 1955), Argentine (Martínez, 1956), Mexico (Herrera, 1960; Léon-Gómez and Pérez-Silva, 1988), Spain (Calonge and Demoulin, 1975), Europe (Dennis, 1986), Portugal (Calonge and Almeida, 1992), Finland (Haeggström, 1997), Canary Islands (Beltrán-Tejera et al., 1998).
Remarks: According to Brodie (1975), this species differs from *C. montagnei*, which is very similar, in its smaller basidiospores, smooth outer and inner surfaces and glabrous mouth. These characteristics closely agree with the material studied. When Persoon (1801) transferred this fungus to the genus *Cyathus*, he simultaneously sanctioned the basyonym (Korf 1983). Following Korf's (1983) interpretation of the 1981 changes to the ICBN, the correct author citation for this name therefore is *Cyathus olla* (Batsch: Pers.) Pers. This is the first record of *C. olla* from Brazil.

Cyathus pallidus Berk. *&* Curt., J. Linn. Soc. Bot. 10: 346, 1896.
Fig. 5
Peridium campanulate, short, 7-9 mm high, 5-7 mm wide at the mouth, broad base attached to the substratum by a light brown (5D4) felt-like pad; outer surface light brown (5D4), smooth, finely strigose to glabrous in mature; inner surface light brown (5D2), smooth; mouth smooth; peridioles lenticular, 1.5-1.8 mm diam., dark grey (3F2), single layered cortex, tunic thin, light brown (5D4); basidiospores ellipsoid, thick-walled, 5-8 x 4-5 µm, smooth, almost hyaline.
Material examined: BRAZIL, São Paulo: Município de Luís Antônio, Estação Ecológica de Jataí, 16/II/1999, I. G. Baseia 320, SP 307493; 02/III/2000; Município de Moji Guaçu, Reserva Biológica de Moji Guaçu, 15/III/1999, I. G. Baseia 360, SP 307492; Município de Itirapina, Estação Ecológica de Itirapina, 19/III/2000, I. G. Baseia 515, SP 307505.
Additional material examined (donated to SP Herbarium): BRAZIL, Rio de Janeiro: Município do Rio de Janeiro, Botanical Garden, 1969, det. D. M. Dring, SP 70951.
Distribution: Puerto Rico (White, 1902), Brazil (Lloyd, 1906), South Africa (Bottomley, 1948), West Indies (Brodie and Dennis, 1954), Argentine (Martínez, 1956), China (Liu, 1984), Mexico (Léon-Gómez and Pérez-Silva, 1988).
Habitat: Gregarious on soil in buried wood from gallery forest and "cerradão", widespread.
Remarks: According to Brodie (1975), *Cyathus pallidus* is easily recognized in its commonest and typical form, but it is an extremely variable species. It is mainly characterized by small cups, light colored, thin-textured, tomentose or smooth when older. As Lloyd (1906) suggested, *C. pallidus*, *C. intermedius* (Mont.) Tul & C. Tul. and *C. triplex* Lloyd probably constitute a species complex including many intermediate forms. Lloyd himself finally decided that *C. sphaerosporus* Lloyd is not distinguishable from *C. pallidus*. Further studies may show that it represents a polymorphic species. Later on, Brodie (1984) proposed to segregate these species according to their macro and microscopic characters.

Cyathus poeppigii Tul. & C. Tul., Ann. Sci. Nat. III, 1: 77, 1844.
Fig. 6

Peridium obconical, 6-8 mm high, 4-6 mm wide at the mouth, arising from a light brown (5D3) mycelial pad; outer surface yellowish-brown (5F5), plicate in upper portion, hirsute; inner surface olive-grey (3F2) to brownish-grey (5F2), shiny, plicate in upper portion; mouth plicate; peridioles lenticular, 2-2.5 mm diam., dark brown (6F6) to black, with two-layered cortex, tunic absent; basidiospores subglobose to broad-elliptic, 22-30 x 18-20 µm, smooth, thick-walled, hyaline.

Material examined: BRAZIL, São Paulo: Município de Luís Antônio, Estação Ecológica de Jataí, 18/III/1999, I. G. Baseia 371, SP 307495; Município de Itirapina, Estação Ecológica de Itirapina, 06/III/2000, I. G. Baseia 496, SP 307508.

Additional material examined (donated to SP Herbarium): BRAZIL, Rio Grande do Sul: Município de São Leopoldo, 1905, det. J. Rick, SP 22908; São Paulo: Município de São Paulo, Serra da Cantareira, 22/VI/1965, coll. and det. B. Lowy, SP 83512.

Habitat: In groups on decaying wood in "cerradão".

Distribution: Cuba and French Guiana (White, 1902), Australia (Bottomley, 1948), South Africa (Bottomley, 1948), West Indies (Brodie and Dennis, 1954), Argentine (Martínez, 1956), Brazil (Rick, 1961; Bononi et al., 1981), Congo (Dissing and Lange, 1962), West Tropical Africa (Dring, 1964), China (Liu, 1984), Mexico (Léon-Gómez and Pérez-Silva, 1988).

Remarks: *C. poeppigii* is very similar to the *C. limbatus*, but it is distinguishable by its very large spores. The ridges on the wall of the basidioma are also rather close together in most specimens. For the reason stated in *C. limbatus*, this name should be cited as *Cyathus poeppigii* Tul. & C. Tul. The taxonomic characteristics of the material were close to those of the additional material examined and those found in the literature.

Cyathus stercoreus (Schwein.: De Toni) De Toni, Saccardo, Syll Fung. 7: 40, 1888.
Basyonym: *Nidularia stercorea* Schwein., Trans. Amer. Phil. Soc., 4: 253, 1834.
Fig. 7

Peridium goblet-shaped, 10-13 mm high, 3-4 mm wide at the mouth, attached to the substratum by a light brown (5D4) mycelial pad; outer surface light brown (5D6), smooth, tomentose or glabrous in age; inner surface brownish-grey (5F1), smooth; mouth smooth; peridioles lenticular, 1.5-2 mm diam., dark grey (3F3) to black, two-layered cortex, devoid of a tunic; basidiospores subglobose, 22-30 x 20-28 µm, very variable in size, smooth, thick-walled, almost hyaline.

Material examined: BRAZIL, São Paulo: Município de Moji Guaçu, Reserva Biológica de Moji Guaçu, 02/III/2000, I. G. Baseia 492, SP 307503.

Additional material examined (donated to SP Herbarium): USA, Iowa: Iowa City, 11/IX/1934, det. G. W. Martin, SP 39106.

Habitat: In groups on buried wood in "cerradão", rare.

Distribution: North America (White, 1902; Coker and Couch, 1928), South Africa (Bottomley, 1948), West Indies (Brodie and Dennis, 1954), Norway (Eckblad, 1955), Argentine (Martínez, 1956), Panama (Garner, 1956), Congo (Dissing and Lange, 1962), Brazil (Bononi et al., 1981), British Isles (Brodie, 1984), China (Liu, 1984), Mexico (Pardavé, 1991; Léon-Gómez and Pérez-Silva, 1988).

Remarks: According to Brodie and Dennis (1954), this species is world-wide distributed and extremely variable, specially concerning with size and color of the basidiomata. This has been pointed out by Lloyd (1906) and exhaustively discussed by

Brodie (1975, 1984). It is characterized by large, subglobose basidiospores, basidiomata variable in size, peridium tomentose becoming glabrous in age. Descriptions of many authors (Bottomley, 1948; Brodie and Dennis, 1954; Eckblad, 1955; Léon-Gómez and Pérez-Silva, 1988) agree in many features with our collection, except for the size of basidiospores, bigger in bibliographical descriptions. *C. stercoreus* may be a polymorphic species with a variation in the size of the basidiospores. Brodie (1975) describes this species as coprophilous and on manured soil, but not in wood. However, our specimens were found growing on lignicolous habitat. According to Korf's (1983) interpretation of the changes to the ICBN enacted in 1981, the authorship of this name would be more appropriately cited as *Cyathus stercoreus* (Schwein.: De Toni) De Toni.

Cyathus striatus (Huds.: Pers.) Pers., Syn. Meth. Fung., 237, 1801.
Basyonym: *Peziza striata* Huds. Flor. Ang. 634, ed. 2, 1778.
Fig. 8
Peridium obconic to campanulate, 10-12 mm high, 7-10 mm wide, usually with a slender base, yellowish-brown (5D4); outer surface yellowish-brown (5D2), plicate in upper part, hirsute; inner surface brownish-grey (5F1), shiny, plicate; mouth at early stage provided with short setae becoming glabrous in age; peridioles lens-shaped, 1-2 mm diam., dark brown (5F3) to black, single layered cortex, tunic present dark brown (5F1); basidiospores ovoid, 14-17 x 7-9 µm, smooth, thick-walled, almost hyaline.
Material examined: BRAZIL, São Paulo, Município de Moji Guaçu, Reserva Biológica de Moji Guaçu, 26/I/1999, I. G. Baseia 310, SP 307499; Município de Luís Antônio, Estação Ecológica de Jataí, 19/V/1999, I. G. Baseia 397, SP 307500; Município de Itirapina, Estação Ecológica de Itirapina, 20/V/ 1999, I. G. Baseia 402, SP 307504.
Additional material examined (donated to SP Herbarium): USA, Iowa, Iowa City, 24/VIII/1939, det. G. W. Martin, SP 42320; Columbia, Maryland, 22/VII/1958, det. P. L. Lentz, SP 50657. MOLDAVIA, Suceava, 20/VIII/ 1961, det. T. Chifu, SP 211975.
Habitat: In groups, on decaying wood or leaves in gallery forest, widespread.
Distribution: North America (White, 1902), Norway (Eckblad, 1955), Brazil (Rick, 1961), Turkey (Watling and Gregory, 1977), China (Liu, 1984), Mexico (Léon-Gómez and Pérez-Silva, 1988), Finland (Haeggström, 1997).
Remarks: This species is easily recognized by its hirsute basidiomata with inner surface striate and shiny. Microscopically, it is characterized by its large ovoid basidiospores. It differs from *C. berkeleyanus* and *C. pallidus*, which generally resemble, in its larger basidiomata, yellowish-brown color and strongly hirsute outer surface, and mouth with short setae and smooth. The taxonomic characteristics of the material studied were close to those of the additional material examined and to those cited in the literature.

Cyathus triplex Lloyd, Myc. Writ. 2, Nidulariaceae, 23, 1906.
Fig. 9
Peridium urceolate to obconical, 6-8 mm high, 3-5 mm wide at the mouth, tapering towards the sessile base, attached to the substratum by a yellowish-brown (5D5) mycelial pad; outer surface yellowish-brown (5D5), hirsute; inner surface olive-grey (3F1), plicate in upper portion; mouth fimbriate; peridioles lenticular, 1.8-2 mm diam., dark grey (3F2) to black, two-layered cortex, tunic absent; basidiospores subglobose to broad-elliptic, 14-15 x 10-12 µm, smooth, thick-walled, almost hyaline.

Material examined: BRAZIL, São Paulo, Município de Luís Antônio, Estação Ecológica de Jataí, 17/II/1999, I. G. Baseia 330, SP 307498.
Habitat: Solitary on decaying wood in "cerradão", rare.
Distribution: Mauritius (Lloyd 1906), Puerto Rico (Overholts, 1926), British Guiana (Brodie and Dennis, 1954), West Indies (Brodie and Dennis, 1954), Argentine (Martínez, 1956), Thailand (Dissing, 1963), Venezuela (Reid, 1976), Mexico (Léon-Gómez and Pérez-Silva, 1988).
Remarks: *Cyathus triplex* generally resembles *C. pallidus*, from which it may be distinguished by its peridium dark colored, more hirsute, large basidiospores and the double cortex of the peridiole. In accordance with Brodie (1979), this is a valid species belonging to the group with two-layered cortex and moderately large basidiospores. These characteristics closely agree with the material studied. *Cyathus triplex* is a new report from Brazil.

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BOOK REVIEWS AND NOTICES[1]

Compiled by
David L. HAWKSWORTH
MycoNova, Calle Aguila 12, Colonia La Maliciosa, Mataelpino, E-28411 Madrid, Spain; and
Departamento de Biologia Vegetal II, Facultad de Farmacia, Universidad Complutense,
Plaza de Ramón y Cajal, Ciudad Universitaria, E-28040 Madrid, Spain

GENERAL

The Mycota. Vol. 7. Part A. **Systematics and Evolution.** Edited by David J. McLaughlin, E. G. McLaughlin & Paul M. Lemke. October 2000 ['2001']. Springer Verlag, Tiergartenstraβe 17, D-69121 Heidelberg, Germany. Pp. xx + 366, 217 figs. ISBN 3 540 58008 5. Price DM 379, US $ 215, £ 215.

This volume begins with an introductory chapter which discusses the nature of the fungi, and then continues with 13 other chapters which cover the parafungi (*Oomycota, Hyphochytriomycota*), protozoan non-fungi (*Plasmodiophorida*), and the various groups of *Zygomycota* and *Ascomycotina.*

Chapter 1, 'What are Fungi?', is a brilliant tour de force. It is engagingly written and persuasively argued. It provides an intellectually stimulating analysis and synthesis of fungi and fungus-like organisms which should be required reading for all aspiring mycologists (and also for those who have arrived). The author points out the basic differences between oomycetes (and other parafungi) and eumycotan or 'true' fungi, and suggests that the descriptor 'fungal' be restricted to attributes found only in true fungi, while the word 'fungoid' would be useful to describe the parafungi and attributes they have in common with fungi. He points out that organisms with a fungoid lifestyle - 'vegetatively walled, plastid-free heterotrophs'- evolved at least six times: three times in the *Chromista*, twice in a the *Choanozoa*, and once to produce the true fungi. The difficulty in defining fungi arises from the multiple origins of fungoid characters, and the subsequent multiple losses of such characters. One surprise is that the *Microsporidia* (e.g. *Nosema*, an anaerobic, intracellular parasite of insects) have now been recognized as true fungi.

Many chapters in Volumes 7A and B (*see below*) treat the available molecular data as holy writ, but in Chapter 1 of Volume 7A we are told that 'rRNA has evolved at such different rates within [the] fungi ...that the trees suffer from systematic biases as well as random noise' and 'Gross inequalities in the rate of rRNA evolution are apparent in *Zygomycetes, Ascomycetes, Basidiomycetes* and *Microsporidia.* These make the construction of phylogenies a rather speculative occupation'. The author suggests that ranking taxa by phylogenetic age or degree of sequence difference is undesirable, and he prefers to use a combination of morphology, rRNA and ecology, weighted in that order. My only substantive criticism of this otherwise outstanding Chapter is the absence of illustrations of the many diagnostic characters that are discussed in detail in the text.

Where Chapter 1 refers to *Chromista*, Chapter 2 (*Peronosporomycetes*) insists on *Straminipila* (elsewhere spelled '*Stramenopila*'). The author also manages to avoid mentioning the name by which this group is best known, *Oomycota*, until the 22nd page of the chapter. These are just two examples of how difficult it would be for the uninitiated to integrate the material presented in Volumes 7A and B with what they have read elsewhere. A positive feature of this Chapter is the extremely good set of definitions provided for technical terms. The group as a whole is also carefully delineated in Section VIII. This Chapter is quite well illustrated with a combination of micrographs and line drawings, but its value would have been enhanced by the inclusion of drawings illustrating diagnostic features of the more common taxa. This comment applies equally to many other chapters in the book.

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[1] Books for consideration for coverage in this column should be mailed to the Book Review Editor at MycoNova (address above) in the first instance. Fax: (+34) 91 857 3640. E-mail: davidh@farm.ucm.es.

Chapter 3 gives a brief description of the *Hyphochytridiomycota*, rather obscure microscopic parafungi about which little is known, as can be gauged from the facts that only two species have been studied in detail, and that it is not known whether sexual reproduction occurs in the group.

Chapter 4 covers *Plasmodiophorida*. The author tries to keep his taxonomic options open, giving alternative affiliations. I would have thought that a consideration of Chapter 1 would have provided a current and authoritative answer. In any case, the group is neither fungal nor fungoid.

Chapter 5 is largely a rerun of the last major examination of the *Chytridiomycota* by the same author (D. J. Barr) published in 1990, with the important addition of a fifth order, the *Neocallimastigales*, which are anaerobes inhabiting the guts of herbivores, and in many cases producing multiflagellate zoospores - a break with the traditional image of chytridiomycetes. Most taxa in this phylum are still based on the classic publications by Sparrow from 1960 and Karling from 1977. Here is what happened to one line in the reference section of the chapter: 'gen. et sp. nov., a chytrid' became the nonsense 'genet sp. nov. achytrid'. So much for proof-reading.

Chapter 6 covers *Zygomycetes*, and is a well-organized and comprehensive treatment, flawed only by the absence of synoptic diagnostic illustrations. I say that, because although the photomicrographs of zygomycetous structures in Figs 1-18 are good, the selection is far from comprehensive, and there is a real need for accompanying interpretive diagrams. Terms are well-defined but there are no accompanying drawings. The illustrations of arbuscules (Figs 19 and 21) fail to convey the beautiful complexity of these structures. The morphology of the *Entomophthorales* is not illustrated.

Chapter 7 is a relatively brief survey of the *Trichomycetes*, a little-known group of arthropod commensals. My only criticism is the entirely inadequate illustrations - a work of this nature calls for as full a set of diagnostic illustrations as possible. The text is a relatively minor update on the classic work by Lichtwardt of 1986.

Chapter 8 catalogues the several groups of ascomycetes without any illustrations (sorry to keep harping on this, but if nothing else, my many years of teaching inculcated the crucial need for good illustrations in all taxonomic documentation). The system adopted by the author does not match those proposed in the series Preface, or in Chapter 1, but does at least coincide with that in the volume Preface. She lists 12 features (e.g. hamathecium), in various combinations of which the orders can be separated, but the beginner will again become lost in the terminological maze, since these terms are neither defined nor illustrated.

Chapter 9 presents a very brief but wide-ranging discussion of ascomycetous yeasts and yeast-like taxa, again inadequately illustrated. An outline of the relevance of yeasts to humans is followed by explanations of yeast reproduction and the taxonomic methods applied to the group. The taxonomic discussion is appropriate for experts, but without detailed illustrations or tabular information it will be of little help to those seeking enlightenment.

Chapter 10 gives a good general account of the monophyletic *Plectomycetes* and their considerable practical importance, and has a useful plate of diagrams that gives the reader some perspective (though Fig. 4a is difficult to interpret, and some of the diagrams should be much larger, since it is impossible to resolve the asci in, for example, Figs 5 and 7). The list of genera is useful, though it would have been helpful to identify the teleomorph-anamorph pairs, where these are known. The classificatory section successfully integrates molecular and morphological information, and produces convincing alignments.

Chapter 11. The *Pyrenomycetes* are also considered largely monophyletic. The authors cogently explain the salient features of the group and give clear diagrams of representatives of the various orders. Although relatively few examples are given for each order, they are usually diagnostic, and are clearly a distillation of the authors' extensive experience and insights. I am glad the authors did not use photomicrographs, since the drawings are clear and informative. It is too bad that the controversy over the nature of the *Laboulbeniales* could not have been resolved before publication of this book (Chapter 1 places them among the *Archemycota* with the *Entomophthorales*).

Chapter 12. The *Discomycetes* are a clearly polyphyletic group. The authors present a comprehensive, but perhaps perforce rather condensed account. Useful sections cover ecology and associations, especially in lichens. The illustrations of ascomatal types are valuable, though sometimes rather too schematic to aid the student's perception of what the real thing looks like (representative generic names would also have been helpful). Various sections of text cover ascomata, asci, ascospores, paraphyses, septal structures, etc., and under *Lecanorales*, two types of asci are mentioned, rostrate and chimney, but of all these terms, only ascomata are illustrated. Good definitions, historical outlines and areas of relevance to humans are given for the various orders. When commenting on anamorphs, the authors are rather vague. To their credit, they list the various published (printed) attempts to provide anamorph-teleomorph correlations, but not the most comprehensive compilation available, which is on the web at http://www.biology.ualberta.ca/jbrzusto/anatcleo/anatel.html. It is unfortunate that the cladogram (Fig. 3) contains no fewer than 4 misspelled names, and in the description of the *Pezizales* the word ‘circumscissile’ is rendered as ‘circumsessile.’ Nevertheless, the authors have compiled a great deal of interesting information about the group, and the truly interested student can gain much from reading this chapter.

Chapter 13 *Loculoascomycetes*. Wordy descriptions of ascomata, hamathecia, and asci are deplorably devoid of illustrations. Again it is obvious that the classification presented is in process of being radically changed. The definitions of orders are expertly done, but the photographs, for example Figs. 6-11 and 12-15, almost all call for explanatory diagrams. The authors are authorities on the group, but I think they have not succeeded in communicating the essential nature of the bitunicate ascomycetes to the seeker after mycological knowledge. I conclude that a lack of truly explanatory illustrations lies at the root of this problem. Should readers have to go elsewhere to learn the nature of the ascus, or the modes of development of the centrum, in these fungi? Is there a prerequisite to this course?

Chapter 14. Anamorphic fungi: a group of asexual ‘states’ forever in taxonomic limbo. And yet it persists, expands, becomes ever more important, and has even been given unnecessary and misleading names such as *Fungi Imperfecti* and (even worse because of its pretence of being a real taxon) *Deuteromycotina*. I have been professionally involved with anamorphic fungi for many years, so was particularly interested in this Chapter. It is very thoughtfully written, and although the illustrations cover only a tiny percentage of the anamorphic spectrum, they present important examples. Table 3, detailing the subdivision of older genera called for because both ascomycetous and basidiomycetous affinities had been discovered, would have benefited from some accompanying illustrations, as would Table 4. A plate explicating the various kinds of conidium ontogeny and secession would also have been helpful, since readers may be unprepared for such words as rhexolytic (explained in Chapter 10) and will not see its alternative, schizolytic. It would also have been helpful to have some direct consideration of the several ways in which catenate conidia (those in linear series) arise. The various kinds of conidiomata (synnemata, sporodochia, pycnidia, acervuli, and intermediates) could have been more clearly described and illustrated. However, there are excellent selections of illustrations covering many of the other categories discussed. I would like to have seen a more comprehensive plate of drawings associated with all of the 16 identified groupings (to be fair, many of them already have such plates). I am glad that the authors did not use photomicrographs, but chose clear, unequivocal line drawings. This chapter shines in its extensive documentation of the links between anamorph and teleomorph, an aspect not adequately covered in several other chapters (though the web site mentioned above under Chapter 12 is not included). I am glad that the authors give their blessing to the abandonment of anamorphic taxa above the generic level, especially the misleading *Deuteromycotina*, since these always pretended to natural qualities they did not possess. A few obscurantist words like ‘acropleurogenous’ (apical and lateral) and ‘micronematous’ (inconspicuous or poorly differentiated) linger. Despite my various carpings, this is a fine chapter that can be read with profit by most mycologists.

Throughout this volume one encounters terms that are familiar only to the cognoscenti, and I for one wish that the authors/editors had provided an introduction to such features. The chapters frequently provide a fine analysis of a group, but the only one to provide a truly illuminating synthesis (Chapter 1) proffers a system so different from those adopted elsewhere in the two volumes that the uninitiated reader is sure to be confused, and perhaps discouraged.

BRYCE KENDRICK
8727 Lochside Drive, Sidney-by-the-Sea, British Columbia V8L 1M8, Canada

The Mycota. Vol. 7. Part B. **Systematics and Evolution.** Edited by David J. McLaughlin, E. G. McLaughlin & Paul M. Lemke. October 2000 ['2001']. Springer Verlag, Tiergartenstraβe 17, D-69121 Heidelberg, Germany. Pp. xx + 259, 120 figs. ISBN 3 540 66493 9. Price DM 279, US $ 159, £ 96.

The classification of fungi is in a state of flux. Molecular data are undermining many traditional categories, and major realignments are becoming routine. This volume comes long before the completion of the re-evaluation, so the categories recognized are not necessarily permanent, as is recognized in the volume preface (wherein the only really unfortunate choice is the recognition of the artificial group *Pseudomycota*, comprising phyla from two different kingdoms).

Perhaps the most serious deficiencies in this book are: (1) the interim state of the fungal classification presented; and (2) the paucity of good illustrations (though this varies from chapter to chapter - a stronger editorial hand would have helped tremendously). The first could not have been avoided except by delaying publication of the volume even further. The second could and should have been remedied.

Chapter 1 presents a succinct summary of the extremely polyphyletic basidiomycetous yeasts. Yeast morphology has arisen time and time again in basidiomycetes - in the rust fungi, the smut fungi, and the *Hymenomycetes*. '*Sporobolomyces*' is represented in all four major clades of urediniomycetous yeasts. '*Cryptococcus*' is represented in all four clades of hymenomycetous yeasts. Such conclusions essentially make mincemeat of the extant classification. Chapter 1 (as well as several others) has minor problems with typos and misspellings such as 'heterogenous', 'flaired,' 'similary,' 'Sakaquchia.' A few binomials are not italicized, while other ranks, such as Urediniomyceetes (sic), and ordinal names are inappropriately italicized. Microbotryales is used instead of *Microbotryum*. Otherwise, this chapter is a stimulating contribution.

Chapter 2. The name *Urediniomycetes* was introduced afresh in 1995 as a monophyletic taxon containing rust fungi (*Uredinales*), *Auriculariales, Septobasidiales, Platygloeales*, some smut fungi, jelly fungi and even a few former hyphomycetes and an 'ascomycete.' This Chapter is inevitably a pot pourri of information. The sheer diversity of morphology, methods of sporulation and habitat is dizzying. The current classification is chaotic. So what holds the group together? DNA sequence data, wall carbohydrates, simple septa, absence of Woronin bodies and of membranous septal pore caps. Microscopic characters seen through the light microscope are no longer helpful - including basidium and basidioma morphology (other Chapters show such statements to be true of several major fungal groups). It is very disappointing that in this Chapter, and many others, there are not more illustrations showing the range of morphology and reproduction of the several component groups. How, in their absence, are students of mycology going to come to grips with the new paradigm? *It appears that morphology will remain important in the discovery and description of new species, but will not suffice to place them in higher taxa.* That statement is becoming a generalization applicable throughout wide swathes of the fungal classification, and has tremendous ramifications.

Chapter 3 covers the *Ustilaginomycetes*. Not all smuts belong here, since some are now placed in the *Urediniomycetes* (!), but the *Exobasidiales* have a new home here. As now constituted, the class may have phragmobasidia or holobasidia, with spores discharged or not. This is a good chapter, which explores most of the angles.

Chapter 4, like many others, uses ultrastructural characters to redefine *Heterobasidiomycetes*, recognizing two subclasses, the *Heterobasidiomycetidae* - *Ceratobasidiales, Tulasnellales, Dacrymycetales* and (most) *Auriculariales*, and the *Tremellomycetidae* - *Tremellales* and *Christianseniales*. There are fine illustrations of basidial and some ultrastructural characters.

Chapter 5 recognizes 8 major clades of *Homobasidiomycetes* - polyporoid, euagaricoid, boletoid, thelephoroid, russuloid, hymenochaetoid, cantharelloid, and gomphoid-phalloid. Just to exemplify the radical classificatory changes proposed, I will note that: (1) the agaricoid clade includes (in addition to many agarics) some *Aphyllophorales* (*Clavariaceae, Fistulinaceae, Polyporaceae* and *Schizophyllaceae*), plus *Lycoperdaceae*, *Nidulariaceae* and *Tulostomataceae*, and a few *Paxillaceae*; (2) the boletoid clade includes forms which are poroid, gilled, resupinate, sequestrate, hypogeous, and even some puffballs; and (3) the thelephoroid clade includes forms which are corticioid, clavarioid, pileate pored, pileate toothed, pileate smooth/wrinkled, and pileate gilled. These examples show how thoroughly the fungal spectrum has been dismembered and reassembled. It will be a while before the full impact and implications of this reorganization can be assimilated and adopted by the mycological public and the popular literature (e.g. field guides). This chapter is particularly disappointing in terms of illustrations, with only one plate showing a range of basidiomata with which all mycologists, including amateurs, are already familiar. However, the authors do discuss a number of interesting aspects, such as anamorphs and biological associations, that are not dealt with in other chapters.

Chapter 6 presents a logical survey of the problems and practices involved in the naming of fungi, and broaches changes, some of which may have radical effects.

Chapter 7 is a routine discussion of the culturing and preservation of fungi.

Chapter 8 presents useful mathematical methods for planning and optimizing taxonomic projects, with recommendations for appropriate software.

Chapter 9 gives a rather theoretical discussion of mechanisms of speciation in fungi.

Chapter 10 presents a really useful assessment of the relative merits of different molecular characters in establishing both phylogenies and the timing of the divergence of major groups. Some of the conclusions are rather counterintuitive, and it will be interesting to see if future fossil discoveries and additional molecular data support these ideas. As the authors conclude 'sequences from more genes and characters of all other types will be welcome'. That may be seen in retrospect as the understatement of the year.

All of this leaves me wondering about the target readership of this volume. Specialists in each group will already have seen most of the ideas aired in the literature. Non-specialists will search in vain in several Chapters for illustrations to illuminate the often extremely confusing changes being proposed. Students (especially those with a bit of mycology under their belts) may be excused for throwing up their hands in dismay. Those new to the discipline won't have a clue what the fuss is all about.

Given the rather alarming number of typos, egregious errors and peculiar English usage in some Chapters, the general paucity of expository illustrations (and the often inappropriate use of SEMs, which frequently present information in a form not readily assimilable unless accompanied by interpretative diagrams), and the extremely uneven quality of the chapters, I am reluctant to recommend the book to the general mycological public, unless they insist on having a precis of an interim, and often confusing, stage in the development of mycological systematics.

Michael Ondaatje recently remarked that 'As a writer, I find that the last two years of any book I work on [are] given over to editing it'. After considering the taxonomic confusion that suffuses Volumes 7A and B, I felt that the Editors might have taken this advice to heart. I suppose that, since the publishers do not pay their authors, they must to some degree take what is provided. But many aspects of these volumes could have been greatly improved by firm editorial hands. Volumes 7A and B provide only an interim snapshot of an evolving intellectual process - the development of a renewed phylogenetic and classificatory system for the fungi. Given that this kind of compilation is carried out only every two or three decades, it might have been better to wait another 5-10 years until more data were available on which to build the new scheme, and to produce more comprehensive and profusely illustrated accounts of the major groups.

BRYCE KENDRICK
8727 Lochside Drive, Sidney-by-the-Sea, British Columbia V8L 1M8, Canada

The Fifth Kingdom. By Bryce Kendrick. February 2001 ['2000']. Focus Publishing/R. Pullins Company, P.O. Box 369, Newport, MA 01950, USA. [Orders: Focus, c/o Publishers Business Services, Box 390, Jaffrey, NH 03452, USA.] Third Edition. Pp. xii + 386. ISBN 1 58510 022 6. Price US $ 40, CAN $ 60.

It is a pleasure to introduce a new edition of this now established text. The first edition appeared in 1985, when the idea that the fungi should be regarded as a kingdom distinct from plants, animals, protozoa and bacteria was really starting to take a hold. The work was so popular that a second edition was released in 1992; this was subsequently reprinted twice. So much has happened in mycology in the 1990s that this third edition was becoming a necessity. I warmed to the new edition immediately as the cover bears a colour photograph of the lichenized agaric *'Omphalina' ericetorum* (the issue of the correct generic name notwithstanding!).

It starts with just over a page hard-sell as to why everyone should study fungi, with questions that bring fungi into the very heart of human concerns. At the same time, there is an appeal to personal environmental action to stop the loss of biodiversity and protect our environment. Yet first and foremost a textbook has to appeal to its intended student audience, and so I market-tested it with Peter Váczi, a final-year undergraduate at the University of P. J. Šafárik at Košice in the Slovak Republic who chanced to be working with me in Madrid when the third edition appeared.

Peter's comments summed up the essence of *The Fifth Kingdom*: 'Very easy to read, and when you start you don't want to end !'; 'Encyclopedic coverage of every side of mycology, not only taxonomy but also ecology, physiology, genetics, etc.'; 'All the time there is some story'; 'Illustrations of life-cycles in different groups welcomed'; 'Many line figures are included throughout'; 'Clear figures which are much better than photographs'; 'Information on where you find fungi in everyday life'; and 'Generally useful for ordinary people who would find sections such as that on biocontrol intriguing'. Bryce's enthusiastic and honest style, not papering over gaps and uncertainties, should also be mentioned. The classification adopted has been updated, with protozoan and chromistan fungi treated in a chapter entitled 'A mixed bag'. There is no separate chapter on conidial fungi, something now routine but pioneered by Bryce in the first edition back in 1985.

A list of 'Further reading' follows each Chapter, but facts are not generally referenced in the text itself. While this means that the sources of many of the fascinating 'tit-bits' cannot be easily identified, it does make the whole easier to read.

There is a glossary and a rather full index, actually fuller than intended in my copy as there are two versions of 'j' through 'z' - the second occupies the last 13 pages of the book but appears to be from an earlier version of the text as the page numbers are out of step. An irritation until one learns to ignore the latter version, but showing that even the most experienced mycologists can have lapses.

This edition is a considerable leap forward from the second, the more so as there is an accompanying CD-ROM with over 1100 colour pictures, a remarkably extensive glossary, and the ability to switch around and marvel at the fifth kingdom. The CD-ROM (see *Mycotaxon* **78**: 506, April-June 2001) is available from Mycologue Publishers (8727 Lochside Drive, Sidney by the Sea, BC V8L 1M8, Canada; US $ 55 or CAN $ 80 for individual use; US $ 135 or CAN $ 200 for library/laboratory yearly licences US $ 270 or CAN $ 400 for class/lecture use).

My one regret is that while the results of molecular phylogenetics are incorporated through the classification used, only one molecular tree appears - and that showing the relationship between kingdoms. This is certainly something to be addressed in any fifth edition as such a framework will be expected by many of today's generation of students. 'Alexopoulos' (i.e. C. J. Alexopoulos, C. W. Mims & M. Blackwell, *Introductory Mycology*, 4th edn, John Wiley, New York, 1996) clearly has a rival, but I suspect that *The Fifth Kingdom* will prove to be more popular amongst beginners and less advanced students - especially if they have access to the CD-ROM.

Micologia 2000. Edited by Associazione Micologica Bresadola. December 2000. Fondazione Centro Studi Micologici dell' Associazione Micologica Bresadola, P.O. Box 296, I-36100 Vicenza, Italy. [Orders to Associazione Micologica Bresadola, Via A. Volta 46, I-38100 Trento, Italy.] Pp. 712. ISBN not indicatd. Price Ll 125,000, € 64.56.

This book is intended to be a mycological celebration of the new millenium. Its realization has involved 90 contributors drawn from 22 countries who together have produced a volume of 56 articles in a variety of European languages. The topics vary enormously in scope, and it is regrettably impractical to mention each. The range is from accounts of individual species of interest to monographic revisions and molecular or incompatibility studies. Perhaps the most important systematic papers are: a revision of *Calloriopsis* and *Gelatinopsis* (with the new genus *Hyalorbilia*) by H.-O. Baral & G. Marson; a molecular and chemotaxonomic study of *Leccinum* showing the genus to be polyphyletic and needing to be restricted to sects. *Leccinum* and *Scabra* by M. Binder & H. Besl; a checklist of African polypores south of the Sahara with 317 species, 32 % of which are endemic, by L. Ryvarden; a survey of boletes in south-east Asia by R. Watling; a revision of *Incrupila* by A. Raitviir; a survey of *Exobasidium* species in Switzerland by B. Ing; a 102 page account of 85 species of pyrenomycetes occuring on dung in Italy with keys, illustrations, full descriptions, and synonyms by F. Doveri, G.Cacialli & V. Caroti; and a beautifully illustrated survey of the truffle genera *Terfezia* and *Tirmania* by, naturally, A. Montecchi.

The whole is well-illustrated by top-quality colour photographs and also coloured drawings, and extremely well-presented. The editorial team are to be congratulated, although I was sad to see *Lactarius* 'Pers. ex Gray' (not 'Pers.' or 'Pers. : Fr.') in the title of one article in such a prestigious publication - does it have to take 20 years or more for mycologists to understand changes made in the *Code* ? Notwithstanding such minutiae, what a way to celebrate the turn of the century ! The whole enthuses with an energy and passion for fungi, and the excitement of discovery. It is also a blend of the amateur and the professional, and forges links across national and lingusitic boundaries. Further, it is gratifying to see the vision of such a work coming from an independent centre and association of mycologists, and it will be interesting to see how the association itself develops in and responds to the challenges of this new century.

Biodiversity and Biogeography of Australasian Fungi. Edited by Tom W. May & S. L. Farrer. 2001. [Australian Systematic Botany 14 (3).] CSIRO Publishing, 150 Oxford Street, P.O. Box 1139, Colingwood 3066, Victoria, Australia. Pp. 184. ISSN 1030 1887. Price A $ 75.

This special journal issue is based on papers presented at the IUMS 9th International Congress of Mycology held in Sydney in 1999. Ten papers are included which vary considerably in their depths of treatment, but which together provide a valuable snap-shot of where we are in our understanding of the Australasian mycobiota.

The whole starts with a particularly valuable overview of the history of exploration of fungi in the continent by T. W. May which points out how much there is to know, with 310 non-lichenized species being described as new since 1997. Sadly, the author seems not to appreciate that lichen names are fungal names and comments that 'the integration of lichens into the fungal kingdom has been advocated' (p. 336) but seems content with the fact that they are excluded from the *Fungi of Australia* series ! Such an approach seems antiquated and means that lichens are not accorded a separate article in the issue. K. D. Hyde reports that 1657 non-lichenized ascomycetes have been reported, estimating that this number may represent only 1.1 % of an estimated 150 K present. In the case of *Rhytismatales,* P. R. Johnston reports that while 82 species are formally named, a further 31 are known but undescribed or unreported - something indicative of our current lack of knowledge. K. Vánky illustrates his system of smut classification by Australian examples in a paper that seems somewhat misplaced in the series. Very much in keeping with the theme, however, is C. Grgurinovic's survey of the situation in several agaric groups: recent studies have raised the number of *Amanita* species known from 79 to 117 in Australia, of *Hygrophoraceae* from 37 to 57 (35 species new to science), and in the case of *Mycena* species being discovered belong to at least four hitherto unrecognized sections in the genus. R. Watling notes that there are 126 named and 53 unnamed boletes in Australia, and estimates that we do not yet know half of those present. The *Aphyllophorales* are surveyed by P. K. Buchanan, who suggests that endemism might be higher than usually expected in these fungi in Australasia. However, it is perhaps the truffle-like 'sequestrate' fungi that reach the zenith of endemism amongst the macromycetes in the region; N. L. Bougher & T. Lebel note that 294 species from 83 genera are know known in Australia and New Zealand, but estimate that these represent only 12-23 % of the 1278-2450 that may actually be present. The situation in 'Fungi anamorphici' is covered by E. H. C. McKenzie - what a phrase to be avoided despite its use in the *Fungi of Australia* and a 'defence' presented here; a table lists 48 genera which are currently endemic in the continent, but does note examples where further species of genera described from the region have later been found elsewhere. The final paper by G. H. Fleet considers yeasts which are evidently still largely unstudied in natural habitats in the region.

In summary, a great initiative which does much to place our knowledge of Australasian fungi in perspective. But further, through its publication in a non-mycological journal it should do much to emphasize how little is known of the Australasian mycobiota to a wide range of 'botanists' in the region.

Fungi of the Caribbean: an annotated checklist. By D. W. Minter, M. Rodríguez Hernández & J. Mena Portales. 2001. PDMS Publishing, 1 Ridgeway Road, Isleworth, Middlesex TW7 5LB, UK. Pp. 946. ISBN 0 9540169 0 4. Price US $ 100.

Weighing in at 2.79 kg, this is the heaviest single mycological volume I have encountered for some time. It represents the culmination of work by numerous mycologists, especially in Cuba and Trinidad and Tobago (portraits in colour of many of these conclude the volume), who endeavoured to catalogue all fungi (in the wide sense, also including lichens) in the region on the basis of published records and herbarium collections. The information was compiled in a database and this work has been produced from the computerized records. The number of records included is a staggering 149 785; these represent 11 268 species. For each species details of the place of original publication of the name, the number of records, the date of the first record, localities, substratum (including host), collections with material (acronyms and accession numbers), and bibliographic records. Synonyms are given under accepted species names and also cross-referenced. Several indices follow: taxonomic (by kingdom, phylum, order, family, etc), country (with individual islands listed separately where appropriate), associated organisms, and substratum. The bibliography is impressive to say the least. This book will now be the basic reference work for Caribbean fungi, and a landmark in our knowledge of fungi of the region. While it will have omissions, especially from collections whose records could not be accessed and incorporated, it provides a starting point for those working in any aspect of mycology who wish to know what is recorded, when, where, and on what in this biogeographically complex region. It is also pleasing to see the close co-operation developed between mycologists in the UK and Cuba in particular which, with funding from the UK Darwin Initiative, made this project realizable. It is to be hoped that such collaboration will continue now this book has appeared and that the databases on which it is based will grow through the years ahead.

ASCOMYCETES

Truffes d'Europe et de Chine. By L. Riousset, G. Riousset, G. Chevalier, M. C. Bardet. 2001. Institut National de la Recherche Agronomique and Centre Technique Interprofessionnel des Fruits et Legumes, Paris, France. [Obtainable from INRA Éditions, RD 10, F-78026 Versailles Cedex, France.] Pp. 184. ISBN 2-7380-09328. Price Ff 295(€ 44.97) [+ postage and packing Ff 30].

This book includes 29 taxa belonging to 26 species of *Tuber*, the most fascinating true truffles. Each taxon treated is given a concise description and beautiful coloured photographs of maro- and micro-characters. Although the classification of species in six groups in the book may be challenged, it does provide an easy way to recognise the species. Prior to the species descriptions and illustrations, a review is made to cover the history, taxonomic position, ascoma structures, morphological and new identification methods of *Tuber*. Two keys to most of the species in the book, and *T. himalayense* which is not included in the species accounts, are also provided.

This book has apparently been stimulated by the influx of truffles from China into the European market, yet while the title of the book implies it treats the truffles of Europe and China, only two species of *Tuber* are mentioned as occurring in the latter country. However, more than 20 species of *Tuber* have been recorded in China and about 10 can be found in the book although it does not state that eight of those occur there. While the title of the book may partly be justified because of this, the species included still are far from providing a complete overview of the Chinese true truffles.

Although the book is evidently written for French readers and is not intend to be a taxonomic reference work on *Tuber* in China, it will be good to have at hand when identifying common European species, especially those appearing in markets.

Y.-J. YAO
Systematic Mycology and Lichenology Laboratory, Institute of Microbiology, Chinese Academy of Sciences, Beijing 100080, People's Republic of China

Eine Revision der lichenicolen Arten der Sammelgattungen *Guignardia* und *Physalospora* (*Ascomycotina*). By Nikolaus Hoffmann & Josef Hafellner. 2000. [Bibiotheca Lichenologica Vol. 77.] J. Cramer in der Gebrüder Borntraeger, D-14129 Berlin, Germany. Pp. 190, figs 62. ISBN 3 443 58056 4. Price not indicated.

Another important treatment of a group of lichenicolous fungi from the Graz stable. Having revised the non-hypocrealean 1-septate hyaline spored pyrenomycetes occurring on lichens in earlier works (e.g. M. Grube & J. Hafellner, *Nova Hedwigia* **51**: 283-360, 1990), those with non-septate ascospores demanded attention. Most had been placed in the genera *Guignardia* or *Physalospora*, but as might be expected the fungi are found to belong to a diverse range not only of genera but also of families and orders. Thirteen genera are treated, either comprehensively or at leat for the simple-spored species: *Baciliopsis, Guignardia, Gyrophthorus, Lichenochora, Myxophora, Obryzum, Physalospora, Roselliniella, Sagediopsis, Telogalla, Thamnogalla, Verrucaria,* and *Zwackhiomyces*. Perhaps surprisingly, only one new genus was found to be necessary, *Telogalla* for the single species on *Xanthoria* familiar to us under the name *Guignardia olivieri*; the genus was referred to the *Verrucariaceae*. One factor restricting the number of new genera was the decision to include simple-spored species in genera formerly only with septate spores, notably *Lichenochora* and *Zwachkiomyces*.

Especially interesting was the use of *Myxophora*, a genus of *Dimeriaceae* originally described for a fungus growing on cyanobacterial films over mosses with one or more cilia on the ends of the spores; five lichenicolous species are now placed in the genus, four newly described and on lichens which have cyanobacterial photosynthetic partners. This suggests that the target for *Myxophora* is the cyanobacteria rather than the lichen fungus, quite a contrast to the situation in the lichenicolous *Dacampiaceae* where the lichenicolous fungi appear to be primarily mycoparasites of the lichen-forming fungus. It was interesting to see a second species of *Gyrophthorus* discovered, and that it was also on an *Umbilicaria* (a member of the systematically rather isolated *Umbilicariaceae*). The placement of the monotypic genus *Thamnogalla* has been a problem since I described the genus in 1980, and the families *Physosporellaceae* and *Phyllachoraceae* have been suggested in the past. Now, on the basis of ascus structure and the delicate interascal filaments and hyaline hyphal exciple, the family *Stictidaceae* (*Ostropales*) is suggested and this seems not unreasonable if it is accepted that the ascoma is an apothecium with a narrow disc. *Lichenochora*, a generic name established by Hafellner in 1989, proves to be pre-dated by *Paralaestadia* (Sacc. & D. Sacc.) Vainio 1921; as the latter has been scarcely used and *Lichenochora* is now well-known the authors indicate that they are proposing the conservation of *Lichenochora*. The need to cast a net widely when looking for possible synonyms is well-made again here by the discovery that *Guignardia fimbriatae* is a synonym of the coelomycete *Lichenosticta alcicornaria*!

The whole work is carefully presented with full descriptions and discussions, and especially fine line-drawings (although I suspect some justifiable and understandable artistic licence with the 'neat' peridial cells in some). There are also 24 photographs, mainly of sections of ascomata, some rather lacking the quality that otherwise characterizes the work, although ones shows the fungal hyphae in and around algal cells in *Mastodia tesslata* particularly well. There is a single key, information on 15 excluded species, and an index including the names of hosts as well as other taxa treated.

Such painstaking revisions are the very foundation of all aspects of the study of fungi, and it is most pleasing to see the Graz tradition of critical revisions of such neglected groups being maintained into the 21st century.

LICHEN-FORMING FUNGI

A Hand Book of Lichens. By Dharani D. Awasthi. 2000. Bishen Singh Mahendra Pal Singh, 23-A New Connaught Place, Dehra Dun, 248001 India. Pp. 145. ISBN 81 211 0181 6. Price: Rs 395, US $ 20 (hardback), Rs 195 (paperback).

The lack of basic textbooks has always been a constraint to an expansion of those with an understanding of lichenology. This has been a particularly acute problem in less developed countries such as India where cost precludes the purchase of such books that are published in North America or Europe. The only previous similar text to have been published in India is *Lichens: a preliminary text* by A. Misra & R. P. Agrawal (Oxford & IBH Publishing, New Dehli, 1978) which while well-intentioned suffered from both a lack of awareness of more recent research and the quality of production.

Dr Awasthi is already well-known as the leading authority on lichens in the subcontinent, and also a monographer, but had not produced a book to introduce new students to the subject. He started work on the project to produce a student text back in 1990, and it is very pleasing that he has found time to bring this to completion since he retired from a life-time of professional lichenology. Further, conscious of his perhaps unawareness of western literature, he also enlisted the help of Professor Mark R. D. Seaward in commenting on a first draft of the entire book.

In addition to overviews of key aspects of the subject, there is also information on collecting, curating, and chemical examination, a glossary, and extensive bibliography.

While the length of time the text has been in production means that it is somewhat dated in parts, as in the section on classification where the last literature reference is to one of Tehler's papers from 1996, the work should be warmly welcomed. It merits wide use not only in the Indian subcontinent but also in other countries that do not have access to western texts.

Lichenology in Indian Subcontinent. By Dharani D. Awasthi. 2000. Bishen Singh Mahendra Pal Singh, 23-A New Connaught Place, Dehra Dun, 248001 India. Pp. iv + 124. ISBN 81 211 0187 5. Price: Rs 395, US $ 20 (hardback), Rs 195 (paperback).

This work falls into four discrete sections. First is a history of the study of lichens in the subcontinent. This incorporates a semi-autobiographical account of the author's own career in lichenology which had its origins back in 1947. The section is extremely well-referenced to Indian work and also discusses interactions with western lichenologists from Veli Räsänen in the 1940s to Mason Hale from the 1970s. The second section is a short five-page overview of lichen diversity in India, an almost impossible task in a few pages and something meriting a book in it self which only Dr Awasthi could currently attempt.

The core of this work is a new checklist. The last checklist was published by Dr Awasthi in 1965 (*Beihefte zur Nova Hedwigia* **1**:1-137, 1965) and included just over 1300 species. The new checklist, however, has over 2450 species, almost a 100 % increase over 33 years. The list is strictly alphabetical by genus, with no references to the sources of records. A list of names used in his two complimentary keys to the macro- (*Journal of the Hattori Botanical Laboratory* **65**: 207-302, 1988) and microlichens (*Bibliotheca Lichenologica* **40**: 1-337, 1991) of India and Nepal which are synonyms of taxa in the checklist is helpfully provided. The main difference is in his acceptance of many of the recent

Parmeliaceae segregates, and also some changes in pyrenolichen generic names. Twenty-one new combinations and one new name are introduced, 16 of these transfers from *Ditremis* to *Pleurotrema*.

The fourth and final section of the book provides keys to common macrolichens in India, including generic descriptions, ecological and distributional notes, and keys to species. This will be immensely valuable to Indian students who do not have access to the author's 1988 macrolichen keys mentioned above.

Dr Awasthi's contributions to lichenology, especially in the Indian subcontinent, have been immense and sustained for over half a century despite problems of isolation and access to literature. This work is in essence a synopsis of where he has taken lichenology in the region over that time. It shows what can be achieved by a determined and able systematist even without the benefit of new technologies, modern communications systems, and international travel now available, and should inspire others working in similarly isolated situations.

Epiftytiske Mikrolaver. By Vagn Alstrup. May 2001. Gads Forlag, Klosterstræde 9, DK-1157 København K, Denmark. Pp. 208, coloured photographs. ISBN 87 12 03141 0. Price DK Kr 249.

Most introductory lichen identification guides focus on macrolichens. Not so this one which covers a wide range of crustose and leprose lichens occurring on wood and bark in Denmark. The work is beautifully illustrated with photographs by Ib Søderberg, and for each species a brief description is provided, including microscopic features, and notes on its distribution inside and outside Denmark. The common names given must surely include many not previously coined in Danish.

The species are grouped into 13 categories separated by a key based mainly on superficial features, although the need for a KOH test may put off some beginners. No keys are provided within the groups, users having to rely on the photographs and text. In some, but not all, cases brief notes on the features of the genus are provided. Something not to be expected in a book of this level, but reflecting the author's interests, is the inclusion of notes on lichenicolous fungi under their hosts. This is welcome as the characters of these fungi can cause considerable confusion amongst newcomers to the subject who take fruit bodies of the invading fungus to be those of the host lichen.

While this neat little book will do much to aid the identification of microlichens on woody substrata in the country, the absence of a list of further reading or even to other Danish lichen texts and checklists may cause some frustration.

As many of the some 300 species treated are rarely, if ever, illustrated in colour, and have wide distributions in Europe or temperate regions more generally, this will be a useful adjunct to any lichenological library.

Guía de Líquenes Epífitos. By Vicent Calatayud Lorente & María José Sanz Sánchez. [2001.] Ministerio de Medio Ambiente, Madrid. Pp. 185, 108 coloured plates. ISBN 84 8014 298 7. Price not indicated.

This guide to lichens growing on trees has been produced within the framework of the Pan-European Programme for Intensive and Continuous Monitoring of Forest Ecosystems. It's purpose is to help non-specialists identify species of bioindicator value in the 53 plots in the survey that are located in Spain. One hundred and eight species are figured in exceptionally good-quality colour photographs. Most are macrolichens, but some distinctive crustose species are also covered (e.g. *Buellia punctata, Chrysothrix candelaris, Graphis scripta*). At the end of the book, the figured species recorded in each of the different 53 plots that are listed in tabular form

Keys are by growth-form and lucidly presented, and the taxa covered are arranged alphabetically in two groups. The first series comprises just the photographs but embedded amongst them are keys to species within the genera when more than one is treated. The second comprises species descriptions and discussions, including chemical tests, notes on habitat and distribution, and further an indication of sensitivity.

The taxonomy used is somewhat conservative, for example in retaining the use of *Parmelia* in the broad sense, but that is perhaps wise for users who will thus find information on the same species in earlier literature easier to locate. More recently introduced names are, however, also given as synonyms.

There is also a well-illustrated introduction to lichens and their features, including some fine half-tones, and an overview of the use of lichens as bioindicators, especially of air pollution. Information on lichen web-sites is a welcome feature, and the bibliography of cited literature is accompanied by lists of recommended further reading arranged by broad topics.

I anticipate that this book will not only be well-used by those involved in the forest health monitoring programme, but also by Spanish speaking amateur lichenologists and students engaged in biodindication studies generally.

BASIDIOMYCETES

Common Florida Mushrooms. By James W. Kimbrough. November 2000. Institute of Food and Agricultural Sciences, University of Florida Extension Services, P.O. Box 110810, Gainsville, FL 32611-0810, USA. Pp. vii + 342, 268 figs (257 in colour). ISBN 0 916287 30 0. Price US $ 19.95.

Jim Kimbrough is renowned as an enthusiastic and lucid teacher in mycology, and this delightful book shows that this reputation is well-deserved. Between 3000 and 5000 mushroom species occur in the southern states, and nearly 1000 have been described as new to science from Florida - mainly through the efforts of W. A. Murrill (1869-1957). A key feature of this work is that many of Murrill's species are illustrated in colour here for the first time. With over 8000 of Murrill's collections preserved in the herbarium in Kimbrough's faculty in Gainsville, the author has been able to ensure names were properly applied to these fungi.

The species are arranged by orders, and often families, with keys to the genera and (or) commoner species in some cases. The text for each species is bulleted to separate information on macroscopic features, microscopic ones, and notes on ecology, identification, or other features. The classification system used is conservative, maintaining a broad concept of, for example, *Agaricales* (incl. *Cortinariales*, and *Russulales*). Interestingly, no attempts to coin common names are made, something unusual in a field guide intended for amateur use but surely something that aids international communication. Notes on edibility are provided, but quite a few are prefixed with a '?' . . . There is also a recipe section juxtaposed to one on toxins, a glossary, and the expected introductory matter on general aspects and collecting.

Most of the photographs are by the author, but he has also been able to use slides from several other leading mycologists, for example Henry Aldrich, Tim Baroni, Gerald Benny, Terry Henkle, and Greg Mueller.

There is no doubt that this superbly designed and illustrated book will do much to encourage field mycology in Florida, but the text is also of international interest because of its coverage of many of Murrill's species. It will therefore be of value to those specializing in genera such as *Agaricus*, *Boletus*, *Lepiota*, and *Russula*.

Mushrooms of Cape Cod and the National Seashore. By Arleen R. Bessette, Alan E. Bessette & William J. Neill. 2001. Syracuse University Press, New York, NY 13244-5160. Pp. xiii + 177, numerous coloured photographs. ISBN 0 8156 0688 5. Price not indicated.

Mushroom guides focussing on relatively restricted areas and which are well-illustrated are a great way to make converts to mycology as they mean that a high proportion of species can be identified. This is especially so for guides dealing with areas where people spend vacations such as Cape Cod. As Arleen states in the Preface, the hope is that the guide will contribute 'to each visitor's greater understanding and appreciation of this special place' which was protected in 1961 through the actions of President John F. Kennedy.

The book starts with a paleoecological and climatalogical account and proceeds to describe the different habitats and the mushrooms associated with them in the area: pitch pine barrens, atlantic white cedar swamp, beech forest, and interdunal bogs. I was pleased to see the importance of mycorrihzas stressed, and basic information on mushroom anatomy and collection. A colour key to the major groups of mushrooms with colour photographs within the keys is a particularly neat way to aid beginners in reaching the relevant part of the text. Detailed descriptions of around 150 species follow, including microscopic information, fruiting seasons, edibility, and numerous other observations. However, it is the colour photographs of the species which follow which I am sure will receive the most attention from non-specialist users. These are generally of a good quality, but I worried a little over the colour reproduction of *Mutinus caninus* which appears with a much pinker stalk than is usual in Europe where it tends to be more orange - but perhaps different species are really involved. Unusual for what is primarily intended as a field guide is the inclusion of two new taxa, *Boletus aurantiioruber* (Dick & Snell) stat. nov. and *B. billieae* sp. nov., but this helps emphasize to readers how little we still know of macromycetes even in the eastern USA. It is not clear, however, how many mushrooms in the area are not treated and the opportunity to include a checklist might have been considered.

The USA is well-known for its record of sponsorship of charitable activities of all kinds. This is taken a stage further here by securing sponsorship for particular photographs from a wide range of individuals and even some specialist mycological societies, a college, and a company. This is an approach that used to be not uncommon in the eighteenth and early nineteenth century but I have not seen this in any other recent mushroom book. A practice for other authors to consider ?

The Bessette's are well-recognized for their careful and authoritative work, and William Neill has detailed knowledge of the area. The work can be strongly recommended to mycologists, naturalists, and vacationers.

401 Funghi. By Antonio Gennari. 2000. Associazione Micologia Bresadola, c/o Giovanni Robich, via Orlanda 141/C, I-30030 Campalto VE, Italy. Pp. 44, 439 colour pictures. ISBN not indicated. Price Ll 57,000, €29.44.

This book has a nice appearance at a first look. Published in hard covers, on which there is a photographic taster of the two main aspects treated inside: fungal morphology and a series of peculiar developments which happen in certain fungi. The volume is composed of 18 chapters, plus a preface, a presentation, two indexes, a glossary, references and 14 cooking recipes.

The first informal chapter is dedicated to the description of abnormal forms of growth in mushrooms. Thirty pictures of very curious and rare carpophores are compared with objects, events, monstrosities, etc., in a very funny style. The introduction deals with several aspects related to the biology, habitat, anatomy, chemical reagents, macro- and micromorphology. Systematics and taxonomy are pointed to briefly, as are observations on toxicity and how to collect mushrooms in the field without causing major damage to the mycelium.

The main part of the book consists of 401 pictures of fungi, which are of a high quality, and have corresponding descriptions. For each species the scientific name, etymology, synonymy, macro- and microscopy , organoleptic features, habitat, edibility, and observations are given.

Within this album there are accounts of six new species recently published by the author: *Stereopsis reidii*, *Lyophyllum microsporum*, *Pseudobaeospora pallidifolia*, *Ramaria arcosuensis*, *Leucoagaricus aurantiovergens*, and *Mycena aurantiistipitata*. As to already described species the following are worth pointing out due to their rarity and interest: *Chalciporus rubinus* (p. 139), *Leccinum carpini* (p. 142), *Xerocomus roseoalbidus* (p. 158), *Omphalina rosella* (p. 197), *Pluteus boudieri* (p. 206), *Crepidotus subverrucisporus* (p. 213), *Pholiota nameko* (p. 245), *Hygrocybe psittacina* (p. 272), *Lepiota boudieri* (p. 330). *Tricholoma bresadolanum* (p.350), *T. joachimii* (p. 356), *T. luridum* (p. 358), *T. pseudonictitans* (p. 362), *Catathelasma imperiale* (p. 375), all species of *Camarophyllopsis* covered (pp. 390-394), *Porpoloma metapodium* (p. 397), *P. pes-caprae* (p. 398), *Agaricus menieri* (p. 409), *A. phaeolepidotus* (p. 411), *Clavaria atrofusca* (p. 448), *C. fumosa* (p. 449), *Clavariadelphus flavo-immaturus* (p.452), *Artomyces pyxidatus* (p. 462), and *Clavicorona taxophila* (p. 463).

On the other hand, some photographs are not good representatives of the corresponding species, e.g.: *Leccinum lepidum* (p. 145) looks like *Boletus impolitus* (p. 130); *Suillus bellinii* (p. 147) appears too pallid; *Entoloma lividum* (p. 199) and *E. lividoalbum* (p. 200) seem to be mistaken; *Pluteus cervinus* (p. 207) is of a poor quality; *Cortinarius caligatus* (p. 229) and *C. calochrous* (p. 230) are difficult to distinguished; *Agaricus arvensis* (p. 399) seems to be *A.. silvicola* to me; *A. macrosporus* (p. 407) and *Ramaria pallida* (p. 461) appear overexposed; and *Gyromitra gigas* (p. 492) seems to be *G. esculenta* according to its cerebriform aspect which is lacking in the former species.

The taxonomy and nomenclature are correct, according to the *Code*, except in the case of *Tuber melanosporum* (p. 511), the name normally used in commercial transactions, where *T. nigrum* has priority. There are a few orthographical errors, for instance *Pleurotus drynus* (p. 171) must be *P. dryinus*.

In conclusion, I consider this work of a great value, with important contributions, which will help both, professional and amateur mycologists. Thus, I congratulate to Dr Gennari for this achievement.

FRANCISCO D. CALONGE
Real Jardín Botánico, CSIC, Plaza de Murillo 2. E-28014 Madrid, Spain

Setas de Madrid (y alrededores). Vol. 3. ***Agaricus*** **L. : Fr.** By Sociedad Micologia de Madrid. 2000. Sociedad Micologia de Madrid, Madrid, Spain. Pp. 156, numerous coloured plates. ISBN 84 607 19073 4. Price not indicated.

This is the fourth or a series of small books that started to be issued in 1997. The first was a *Guía de Iniciacíon,* and the other volumes focussed on *Boletales* (1998) and *Gasteromycetes* (1999). This volume covers 52 species and varieties of *Agaricus* found in and around the Comunidad de Madrid, all illustrated by first-rate colour photographs and with full descriptions. In addition, there is a fine series of photographs illustrating features such as the type on annulus, details of the bases, and flesh (with colour changes on cutting or bruising) preceding a dichotomous key to the taxa. Information on edibility, habitats, and possible confusions with other species are provided, but interestingly common names are not provided. With such works available, it is no surprise that mycologists in this part of Spain know their mushrooms so well. Interestingly, the series is self-financing. After the first volume appeared, sales of that and each subequent volume have been sufficient to enable an additional number to be published each year. This is an approach to mycological publishing that might only work in a region where so many people are captivated by mushrooms of all kinds.

CONIDIAL FUNGI

The Deuteromycetes - Mitosporic Fungi. By E. Kiffer & M. Morelet. 2000. Science Publishers, P.O. Box 699, May Street, Enfield, NH 03748. USA. Pp. 300. ISBN 1 57808 068 1. Price US $ 85, £ 56.

Having taught fungal taxonomy for many years, I know how hard it can be to communicate the intricacies of the anamorphic fungi to undergraduates. Here is a book which attempts that feat. How well does it succeed?

The authors chose an unfortunate title, just when the consensus among most mycologists is to avoid using taxa above the generic level for anamorphic fungi, since these have no phylogenetic reality (*Deuteromycetes* is a name at the rank of class). Fortunately, the subtitle puts us back in the right frame. It would have been helpful if the authors had used the word now most widely applied to asexual reproductive phases of the *Dikaryomycota,* anamorphs.

In 1979 I wrote 'It is now clear that there will be no natural classification of the Fungi Imperfecti based on conidium ontogeny'. This statement was recently quoted approvingly by Seifert & Gams (2001), writing about anamorphic fungi in Volume 7A of *The Mycota* (*see above*). It is, then, mildly surprising to discover a book which sets out to prove the opposite. The basic premises of this book, its alpha and omega, lie in development.

The translation is quirky, using such rare or unusual words as ‘amerosporate’ for amerosporous, ‘fimicolous’ for coprophilous or dung-inhabiting, ‘fructiferous’ for sporulating, ‘gustative’ for flavour, ‘individualized’ for differentiated or distinct, ‘integuments’ for skin, ‘muticate’ for without setulate appendage, ‘mycorrhizian’ for mycorrhizal, and ‘telluric’ for soil-inhabiting. The word ‘fumagines’ is used (p. 171) but not defined (I think the authors mean sooty moulds).

The first 35 pages are devoted to explaining a comprehensive (and perhaps rather intimidating) lexicon of specialized terms that apply to anamorphic fungi. While most are necessary, some, such as micronematous, semi-micronematous and macronematous, could easily be replaced by ordinary and generally understood words. The use of the word cilia on p. 21 is inappropriate, since these appendages have nothing to do with motility, and lack the 9+2 internal anatomy. The introduction of two new major categories of anamorphic fungi - hyphales and conidiomales - has a certain logic, but these are not congruent with the accepted groupings, and can only lead to confusion (especially since *Penicillium* fits into both).

Each developmental category is introduced by ‘time-lapse’ sketches, drawings interpreting electron micrographs, and a detailed explanatory text. A dichotomous key to genera is given, followed by plates of often rather simplified (sometimes altogether too sketchy) line drawings, pigment being indicated by rather crude stippling. Each plate is accompanied by a page of detailed legends providing such additional information about each genus as geographical distribution, substrates, holomorph and references.

Chapters 2 to 13 deal with the various developmentally defined groups. In Chapter 3 the term ‘vegetative point’ is used instead of the widely accepted ‘conidiogenous locus.’ Setae, though clearly visible in many illustrations (see Plate XH) are not defined in the glossary.

My major complaints, then, are three: (1) That in a book purportedly aimed at facilitating identification, the user is forced to use developmental characters that are often hard to observe or to interpret. This reviewer still thinks that morphologically similar forms should be grouped together, and their developmental characters sought for subsequently. In the case of isolated spores (as encountered in aerobiological studies), these characters are likely to be unavailable, and that would make this book extremely difficult to use. (2) That a significant proportion of the illustrations are too reduced and rudimentary. And (3) that the dichotomous keys have as many as 361 couplets, making them so unwieldy as to be essentially unusable.

However, with Carmichael *et al.*'s (1980) *Genera of Hyphomycetes* long out of print, and the next edition not yet forthcoming, would-be identifiers may well seek solace in this book. It has the considerable virtues of being comprehensive, and of containing vast amounts of highly condensed but useful information. Now if only all this could be put into a random-access database management program.

BRYCE KENDRICK
8727 Lochside Drive, Sidney-by-the-Sea, British Columbia V8L 1M8, Canada

Integration of Modern Taxonomic Methods for *Penicillium* and *Aspergillus* classification. Edited by Robert A. Samson & John I. Pitt. 2000. Harwood Academic Publishers, 6th Floor, Amsteldijk 166, 1079 LH Amsterdam, The Netherlands. Pp. xii + 510. ISBN 90 5823 159 3. Price US $ 95, £ 63, € 105.

On observing the title of this book, one might think that it was a handbook or manual for the identification of two relevant anamorph genera, *Penicillium* and *Aspergillus,* with an homogenous content and covering all the accepted species. However, this is not the case, nor was this intended by the editors. In fact, the book is a compilation of the papers presented in the 3rd International Workshop on *Penicillium* and *Aspergillus* held in Baarn, The Netherlands, in 1997. The contents are organised as 36 papers divided into nine chapters, and although 26 corresponding contributors are mentioned in the Preface many more authors are included in the headings to the different articles. In these workshops, organised by the IUMS International Commission on *Penicillium* and *Aspergillus,* the most important aspects of the systematic and nomenclature of these genera are addressed. The books derived from these workshops are reference points for those people interested in the taxonomy of *Eurotiales.*

Although some of the papers have been updated since their presentation, after such a long lapse of time (more than three years) some articles have inevitably become somewhat old. However, the publication of identification literature is always a welcome event, especially when such large taxonomic groups are covered.

Chapter 1 is extremely useful since it deals with some complicated nomenclature aspects of these fungi. It also includes a list of the species of *Trichocomaceae*, accepted until 1999, and their synonyms. Chapters 2, 3 and 5 include a mixture of papers, which integrate morphological and physiological techniques applied with more or less success in the taxonomy of these fungi. The synoptic computerised key provided by K.A. Seifert for the identification of *Aspergillus* works perfectly, as I have experienced. Chapters 4, 6 and 7 comprise 17 papers based on molecular taxonomy and phylogenetic analysis of both genera and their teleomorphs, although some taxa are treated more extensively than others. Chapter 8, devoted to pathogenic species of these genera includes only two articles concerning *A. fumigatus* and related species. Someone might have hoped to find some information on *P. marneffei*, the most important pathogenic species of *Penicillium.*

Overall, this is a very well produced compilation. The clarity of the text and the high expertise of all the authors guarantee the book a large audience among mycologists and other professionals interested in these common and important fungi.

JOSEP GUARRO
Facultad de Medicina, Universitat Rovira i Virgili, Reus, Spain

MISCELLANEOUS

Fungal Conservation: issues and solutions. Edited by David Moore, Marijke M. Nauta, Shelley E. Evans & Maurice Rotheroe. 14 June 2001. Cambridge University Press, The Edinburgh Building, Cambridge CB2 2RU, UK. Pp. x+ 262. ISBN 0 521 80363 2. Price £ 65, US $ 95.

This book, a Special Volume of the British Mycological Society, includes papers presented at two different symposia held in 1999, one by the British Mycological Society in Kew and the other during the 13th Congress of European Mycologists in Alcala de Henares in Spain. The papers from the meetings are supplemented by six invited additonal contributions. While not concerned with the systematics of fungi *per se*, systematics is the very foundation of conservation and many of the contributors are well-known fungal systematists. As the title suggests, the focus is on issues, but examples of solutions and actions drawn from a wide range of countries are incorporated. If you are active in, or wish to become active in, fungal conservation this is a book to be seen and pondered.

A Dictionary of Plant Pathology. By Paul Holliday. May 2001. Cambridge University Press, The Edinburgh Building, Cambridge CB2 2RU, UK. Second edition. Pp. xxi + 536. I|SBN 0 521 59458 8. Price US $ 44.95.

It is a pleasure to report the issue of the second edition, published in hardback in 1998, in paperback. Some corrections are stated to have been made since the hardback version was published, but these must be of a minor nature as the overall pagination remains unchanged. If you don't have a copy of the hardback (now priced at US $ 120) in your departmental or laboratory library, this is a standard reference work to consider adding to the next purchase order.

The Cambridge Illustrated Glossary of Botanical Terms. By Michael Hickey and Clive King. 2000. Cambridge University Press, The Edinburgh Building, Cambridge CB2 2RU, UK. Pp. xii + 208. ISBN 0 521 79080 8 (hardback), 0 521 79401 3. Price £ 18.95 (paperback).

This glossary comprises two sections, 46 pages of definitions of terms and 127 pages of line illustrations. While most is of little relevance to the description of fungi, attention is drawn to it here primarily because of the section on leaves (pp. 101-112) which incorporates terms used for a wide variety of shapes, margins, bases, and apices. Some of these are already used in mycology, and others perhaps could be when describing spores in particular. A useful adjunct to a general botanical library and one that might be turned to when an unusual spore has to documented.

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Page 18 & 19, line 1	for	*bertholletaie*	read	*bertholletiae*
Page 122, line 27	for	*kefyer*	read	*keyfyr*
Page 134, line 46	for	*holmi*	read	*holmii*
Page 136, line 1	for	*infirmro-miniatus*	read	*infirmo-miniatus*
Page 137, line 11	for	*maxianus*	read	*marxianus*
Page 138, line 1	for	*kefyer*	read	*keyfyr*
Page 153, line 45	for	*Dermatium*	read	*Dematium*
Page 160, line 35	for	*Dermatium*	read	*Dematium*
Page 203, line 12	for	*ineaqualis*	read	*inaequalis*
Page 249, line 2	for	*leavis*	read	*laevis*

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This index includes names of genera, infrageneric taxa, species, and infraspecific taxa, as well as new names of suprageneric taxa. All new names are in CAPITALS. The page number on which a new name is proposed is followed by an asterisk (*).

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EDITOR-IN-CHIEF
Department of Cryptogams
Institute of Botany
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David L. Hawksworth
BOOK REVIEW EDITOR
MycoNova, Calle Aguila 12
Colonia La Maliciosa, Mataelpino
ES-28411 Madrid
Spain

Karen D. Gettelman
INDEX EDITOR
7044 Amherst Avenue
St. Louis, MO 63130
U. S. A.

Gregoire L. Hennebert
FRENCH LANGUAGE EDITOR
32 Rue de l'Élevage
B-1340 Ottignies - LLN
Belgium

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